US-PAT-NO: 6163622

DOCUMENT-IDENTIFIER: US 6163622 A

TITLE: Image retrieval system

DATE-ISSUED: December 19, 2000

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
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Desai; Ranjit P.	Framingham	MA	N/A	N/A

US-CL-CURRENT: 382/170, 382/305 , 707/6

ABSTRACT:

In an **image retrieval system, a database with a large number of images** is searched to find one or more images meeting the specification of a user. This specification is given in the form of a query image. The system determines the similarity between the query image and a particular image from the database by comparing the **color histograms** of the two images. The histograms are treated as statistical distributions and the similarity is determined on the basis of an information theoretic measure of the distributions. In a first embodiment, the similarity is determined using the Kullback informational divergence of the two histograms. In a second embodiment, the

similarity is based on the entropy
of the distribution of similarity coefficients of
the two histograms is used.

9 Claims, 5 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 4

---------- KWIC ---------

Abstract Text - ABTX (1):

In an **image retrieval system, a database with a large number of images** is
searched to find one or more images meeting the
specification of a user. This
specification is given in the form of a query
image. The system determines the
similarity between the query image and a particular
image from the database by
comparing the **color histograms** of the two images.
The histograms are treated
as statistical distributions and the similarity is
determined on the basis of
an information theoretic measure of the
distributions. In a first embodiment,
the similarity is determined using the Kullback
informational divergence of the
two histograms. In a second embodiment, the
similarity is based on the entropy
of the distribution of similarity coefficients of
the two histograms is used.

Brief Summary Text - BSTX (2):

The invention relates to an **image retrieval system which includes a database**

with candidate images, an entry unit for entering a query image, and a first histogram unit for deriving a first query **color histogram** from the query image.

Brief Summary Text - BSTX (3):

A second histogram unit derives a first candidate **color histogram** from a particular candidate image. Also a determining unit determines a first similarity between the particular candidate image and the query image on the basis of the first candidate **color histogram and the first query color histogram, and a retrieval unit retrieves of the particular candidate image**.

Brief Summary Text - BSTX (7):

An **image retrieval** system and a method as described above, are known from the article "Tools and Techniques for Color **Image Retrieval**", John R. Smith and Shih-Fu Chang, Proc. SPIE--Int. Soc. Opt. Eng (USA), Vol. 2670, pp. 426-437. The **image retrieval** system includes a database with a large number of images. A user searching for a particular **image specifies a query image as to how the retrieved image** or images should lock like. Then the system compares the stored images with the query image and ranks the stored image according to their similarity with the query image. The ranking results are presented to the user who may **retrieve one or more of the images**. The comparison of the query image with a stored image to determine the

similarity may be based on a number of features derived from the respective images. The article describes the usage of a **color histogram** as such a comparison feature. When using the RGB (Red, Green and Blue) representation of an image, a **color histogram is computed by quantizing the colors** within the image and counting the number of pixels of each color. To determine the similarity, a number of techniques are described to compare the two **color histograms** of the respective images. The histogram euclidean distance is a simple measure calculated by comparing identical bins in respective histograms. No cross-wise comparison is made between different bins which represent perceptually similar colors. Furthermore, techniques for determining a histogram intersection and techniques for determining a histogram quadratic distance are described. As an alternative to the histogram techniques, a comparison technique based on color sets is described. In this technique the color of a pixel is compared with a predetermined threshold. If the color is below the threshold, the pixel does not become a member of the set and otherwise it does become a member. A disadvantage is that a large number of pixels, all below the threshold, will not contribute in the comparison in any way. Furthermore, there is no discrimination between values above the threshold. The prior art techniques for determining the similarity between the candidate image and the query image are complex to execute and/or are occasionally not

adequate enough.

Brief Summary Text - BSTX (9):

It is an object of the invention to provide an **image retrieval** system of the kind set forth with an improved mechanism for determining the similarity between the candidate image and the query image. This object is achieved in an **image retrieval** system having the determining unit arranged to, determine the first similarity on the basis of information conveyed by the first candidate **color histogram** in response to information requested by the first query **color histogram**. Determining the similarity between the respective images using an information theoretic measure is superior to the known techniques. The **image retrieval** system according to the invention is better able to establish the similarity between the query image and the images in the database. So, the **image retrieval system according to the invention is superior in finding similar images** and in avoiding images that are not similar enough. Furthermore, the calculation of the information theoretic measure requires less computational effort than the known techniques.

Brief Summary Text - BSTX (10):

An embodiment of the **image retrieval** system according to the invention uses a Kullback informational divergence. The Kullback informational divergence is a measure for determining how different one statistical distribution is from

another statistical distribution. The inventor has realized that a **color histogram** can be treated as a statistical distribution and that the Kullback informational divergence can be applied for comparing the candidate **color histogram with the query color histogram**. Experiments have shown that **retrieval of images** on the basis of a similarity obtained from applying the Kullback informational divergence on the respective **color histograms** gives very good results. Furthermore, the calculation of the Kullback informational divergence requires less computational effort than the known techniques, which is very important since a large number of candidate images may need to be compared with the query image.

Brief Summary Text - BSTX (11):

Another embodiment of the **image retrieval** system also considers entropy of similarity coefficients. By determining the entropy of the distribution of the similarity coefficients, an indication of the flatness of this distribution is obtained. Since a particular similarity coefficient indicates the similarity between the candidate **color histogram and the query color histogram** for the particular bin, the obtained flatness is a measure for the similarity of the candidate **color histogram and the query color histogram** over all bins. Experiments have shown that **retrieval of images** on the basis of a similarity based on the entropy measure gives very good results. Furthermore, the

calculation of the entropy requires less computational effort than the known techniques, which is very important since a large number of candidate images may need to be compared with the query image.

Brief Summary Text - BSTX (12):

A further embodiment of the **image retrieval** system according to the invention compares two **color histograms** of respective regions of the candidate image with two **color histograms** of corresponding regions of the query image, the spatial information in the respective images being employed when determining the similarity. This improves the accuracy of determining the similarity between the candidate image and the query image and a better discrimination among the images in the database can be achieved.

Drawing Description Text - DRTX (4):

FIG. 2 schematically shows an **image retrieval** system according to the invention with multiple **color histograms** per image,

Detailed Description Text - DETX (2):

FIG. 1 schematically shows an **image retrieval** system according to the invention. The system 100 includes a database 102 with a potentially large collection 104 of images. A purpose of such a system is to **retrieve from the collection one or more images** that match the wishes of a user of the system. Those wishes are specified via a query image 106,

which the user can enter into the system via entry means 108. The entry unit may allow the user to compose the query image from a number of existing images or to create the query image from scratch. The system compares the query image with the candidate images in the database and determines for each candidate image how similar it is to the query image. The system ranks the candidate images according to the established similarity. The system 100 compares images on the basis of their **color histogram**. To this end, the system includes first histogram unit 110 to determine a query **color histogram** 112 from the query image 106. The process of determining a **color histogram** from an image is explained in FIG. 3 below. The system also includes second histogram unit 114 to determine a candidate **color histogram** 116 from a particular candidate image 118. The first histogram unit and the second histogram unit may be integrated into one histogram means, which can act on the query image for generating the query **color histogram** and on the particular candidate image for generating the candidate **color histogram** respectively. The system further includes determining unit 120 to determine a similarity 122 on the basis of the query **color histogram 112 and the candidate color histogram** 116. Based on the similarity, the system presents a ranking of the candidate image on a display 126. The user may select an **image from this ranking which is retrieved** from the database via retrieval means 124 for further processing. This further processing may

include temporarily storing
the image in a file 128 for further selection.
This may be implemented as that
the system **retrieves a number of candidate images**
and stores these in the file
128, from where the user makes a final selection as
to which image is desired.
In such a way of working, the system makes a first
selection from the large
collection in the database 102 and the user selects
the image or images from
the much smaller collection in file 128.

Detailed Description Text - DETX (3):

In a first embodiment of the **image retrieval**
system according to the
invention, the two **color histograms** between which a
similarity must be
determined are treated as two probability
distributions. The question as how
similar the two histograms a can then be answered
by measuring how different
the one probability distribution is from other.
This difference between two
statistical distributions is called informational
divergence or Kullback
informational divergence and is calculated with the
following equation:
##EQU1## In which: Q(x) is the normalized query
color histogram,

Detailed Description Text - DETX (11):

In a second embodiment of the **image retrieval**
system according to the
invention, similarity coefficients are determined
for each pair of
corresponding bins of the two **color histograms**
between which a similarity must

be determined. Subsequently the obtained collection of similarity coefficients is treated as a probability distribution and the question as how similar the two histograms are, is then answered by analyzing this probability distribution. In this embodiment, the similarity coefficients are calculated using the following equation: ##EQU4## In which: r.sub.i (P,Q) is the similarity coefficient between bin i of the candidate **color histogram** and bin i of the query **color histogram,**

Detailed Description Text - DETX (24):

In the embodiments of the **image retrieval** system described above, a single **color histogram** is made from the whole image. Because of this, the spatial information from the image is lost and the comparison of two images reflects only global similarity. For example if a user enters a query **image with a sky at the top and sand at the bottom, the retrieved images** are expected to have a mix of blue and beige, but not necessarily a sky and sand. A desirable result for the **retrieved candidate images** would be images with blue at the top and beige at the bottom. In order to achieve this result, a further embodiment of the system according to the invention determines a **color histogram** for a number of respective regions of the query image and compares these determined histograms with histograms of corresponding regions of the candidate image. The query image may be divided into regions using pre-fixed boundaries, e.g.

the division of the image into a number of rectangles. Furthermore, the regions may be indicated manually by the user taking into account important objects in the query image. In this way, the user forces that a histogram is made for a region comprising the object of interest. The choice of the region size is important since it governs the emphasis that is given to local information. In one extreme, the whole image is considered as a single region so that only global information is used for the comparison. In the other extreme, the region size matches the individual pixels. In one of the further embodiments of the **retrieval system according to the invention, the images** are divided into 4.times.4 rectangular regions.

Detailed Description Text - DETX (25):

FIG. 2 schematically shows an **image retrieval** system according to the invention with multiple **color histograms** per image. In this system, the first histogram means 110 determine a first query **color histogram** 202 of a first region of the query image 106 and a second query **color histogram** 204 of a second region of the query image 106. In the same way, the second histogram means 114 determine a first candidate **color histogram** 206 of a first region of the particular candidate image 118 and a second candidate **color histogram** 208 of a second region of the particular candidate image 118. The example in FIG. 2 shows 2 **color histograms** per image, but this is mainly for the purpose of

illustration since in practice the system will have more than 2 **color histograms** per image, for instance 8 or 16. In a subsequent step the determining means 120 of the system makes multiple pair-wise comparisons of the respective **color histograms** and determines a similarity for each comparison. These individual similarities are combined into one overall similarity indicating how similar the candidate image and the query image are, taking into account the local information. The determining means determine a first similarity 210 on the basis of the first query **color histogram** 202 and the first candidate **color histogram** 206. This first similarity 210 indicates how similar is the first region of the query image 106 to the first region of the candidate image 118. The determining means further determine a second similarity 212 on the basis of the second query **color histogram** 204 and the second candidate **color histogram** 208. This second similarity 212 indicates how similar is the second region of the query image 106 to the second region of the candidate image 118. Subsequently, the determining means determine an overall similarity 214 on the basis of the first similarity 210 and the second similarity 212. This overall similarity 214 indicates the similarity between the query image 106 and the candidate image as a whole, taking into account the local information captured through the division in regions. The overall similarity 214 is used to rank the candidate images stored in the database 102.

Detailed Description Text - DETX (50):

FIG. 5 shows an overview of the method according to the invention. In a first step 502, a query image is obtained containing the wishes of the user. This image may be composed from existing images or may be sketched by the user, possibly on the basis of an existing image. Then in a second step 504, a query **color histogram** of the query image is determined. This query **color histogram** will be used in comparing the query image with candidate images from a database. In a third step 506, a candidate **color histogram** of one of such candidate images is obtained. Preferably this candidate **color histogram** has been prepared in advance at the moment the candidate image had been stored in the database. Then obtaining the candidate **color histogram** now, comes down to simply retrieving the histogram. Alternatively, the candidate **color histogram** could be created at this instant, i.e. at the time when it is needed. When the candidate **color histogram** has been obtained, the similarity between the query image and the candidate image is determined in a determining step 508. If in a comparison step 510 it is ascertained that the images are similar enough, the particular candidate **image is retrieved** from the database in retrieval step 512. The particular candidate image may be directly presented to the user or may be temporarily stored in a file for later inspection. Then in step 514 it is determined whether all candidates images in the

database have been dealt
with. If this is not the case, a candidate **color histogram** of a next candidate
image is obtained in step 506 and the process is repeated for this next
candidate image.

Claims Text - CLTX (9):
retrieval means for retrieval of the selected candidate image, selection
thereof being determined by the determining means on the basis of information
conveyed by the first candidate **color histogram** in response to information
requested by the first query **color histogram**.

Claims Text - CLTX (10):
2. An **image retrieval** system according to claim 1, wherein the determining
means are arranged to determine the first similarity on the basis of the
Kullback informational divergence between the first candidate **color histogram**
and the first query color histogram.

Claims Text - CLTX (14):
4. An **image retrieval** system according to claim 1, wherein the determining
means are arranged to determine the first similarity on the basis of the
entropy of the distribution of said similarity coefficients over the bins of
the first candidate **color histogram** and the bins of the first query **color**
histogram.

US-PAT-NO: 6430312

DOCUMENT-IDENTIFIER: US 6430312 B1

TITLE: Image subregion querying using color correlograms

DATE-ISSUED: August 6, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Huang; Jing	Ossining	NY	N/A	N/A
Kumar; Shanmugasundaram Ravi	San Jose	CA	N/A	N/A
Mitra; Mandar	Calcutta	N/A	N/A	IN
Zhu; Wei-Jing	Ossining	NY	N/A	N/A

US-CL-CURRENT: 382/165, 382/162

ABSTRACT:

A color correlogram (10) is a representation expressing the spatial correlation of color and distance between pixels in a stored image. The color correlogram (10) may be used to distinguish objects in an image as well as between images in a plurality of images. By intersecting a color correlogram of an image object with correlograms of images to be searched, those images which contain the objects are identified by the intersection correlogram.

18 Claims, 4 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 4

---------- KWIC ---------

Brief Summary Text - BSTX (6):

Color histograms are commonly used as feature vectors for **image retrieval** and for detecting cuts in video processing because histograms are efficient to compute and insensitive to camera motions. Histograms are not robust to local changes in images, so false positives easily occur using histograms. Though the histogram is easy to compute and seemingly effective, it is liable to cause false positive matches, especially where databases are large, and is not robust to large appearance changes. Another disadvantage of the **color histogram** is insensitivity to illumination changes. Recently, several approaches have attempted to improve upon the histogram by incorporating spatial information with color. Many of these methods are still unable to handle large changes in appearance. For instance, the color coherence vector (CCV) method uses the image feature(s), e.g. spatial coherence of colors and pixel position, to refine the histogram. These additional features improve performance, but also require increased storage and computation time.

Brief Summary Text - BSTX (24):

Experimental evidence shows that the color correlogram outperforms not only **color histograms** but also more recent **histogram refinements such as the color** coherence vector method for **image indexing and retrieval**.

US-PAT-NO: 6647141

DOCUMENT-IDENTIFIER: US 6647141 B1

TITLE: User interface of query by color statistics

DATE-ISSUED: November 11, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Li; Zhouning	San Jose	CA	N/A	N/A

US-CL-CURRENT: 382/162, 382/164 , 382/165 , 382/168 , 382/170 , 382/171

ABSTRACT:

A system and method for manipulating a histogram to perform query by color statistics are described. In one embodiment, color elements of an object based upon a color space are quantized and a histogram is created from the color elements. Further, the histogram is manipulated and displayed. In one embodiment, a database of images is queried by comparing the edited histogram with at least one existing histogram maintained in the database and at least one image corresponding to the at least one existing histogram is displayed.

38 Claims, 15 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 15

---------- KWIC ---------

Brief Summary Text - BSTX (10):

A **color histogram** may provide a convenient graphical interface to the **retrieval of images** that are similar in overall color content and provides a definition of the color representation of an image. The **color histogram of an image describes its color** distribution. Every pixel in the image corresponds to a point in a three-dimensional color space in which a similar image set may be selected based on the color distribution

US-PAT-NO: 6658168

DOCUMENT-IDENTIFIER: US 6658168 B1

TITLE: Method for retrieving image by using multiple features per image subregion

DATE-ISSUED: December 2, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Kim; Hyeon Jun	Kyonggi-do	N/A	N/A	KR

US-CL-CURRENT: 382/305, 382/165 , 707/104.1

ABSTRACT:

An efficient method for retrieving an image using multiple features for an image subregion is disclosed. The present invention obtains a regional representative color for the subregions and uses the regional representative color during a retrieval of a similar image if the regional representative color is reliable. Otherwise, a feature information other than the regional representative color is used.

19 Claims, 4 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 2

---------- KWIC ---------

Brief Summary Text - BSTX (7):

In another **image retrieving** method, the colors of all pixels in a subregion are represented with a plurality of values, such as **color histogram** and the image is represented using the values as the subregion information to **retrieve an image**. Although this method may perform better, due to the use of the plurality of color values, a longer retrieval time is necessary. For example, when using a **color histogram** of nth dimension, a comparison of n elements is required.

Detailed Description Text - DETX (11):

FIG. 1 shows a flowchart of a method for **retrieving an image** in accordance to the preferred embodiment of the present invention, where an image is divided in length and width directions by a fixed ratio, i.e. into grid regions, and each grid region or cell units. Thereafter, a regional representative color C for each cell and a confidence measure of the regional representative color C, a set of main **colors such as a histogram** H, and texture information such as an edge direction component are extracted (S10.about.S30).

Detailed Description Text - DETX (19):

Although the preferred method for **retrieving an image** uses a combination of

both a **color histogram** and a texture information in a similarity determination when the confidence measure of a regional representative color C is less than the threshold value, only one additional feature may be used by setting one of either A or B to zero. Alternatively, one of steps S20 or S30 for obtaining a **color histogram** or a texture histogram may be eliminated to simplify the system. In such case, the weight value for the corresponding feature information would be set to zero.

US-PAT-NO: 6542632

DOCUMENT-IDENTIFIER: US 6542632 B1

TITLE: Method for image characterization using color and texture statistics with embedded spatial information

DATE-ISSUED: April 1, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Qian; Richard	Vancouver	WA	N/A	N/A
Van Beek; Peter J. L.	Vancouver	WA	N/A	N/A

US-CL-CURRENT: 382/165, 382/299 , 382/305 , 707/104.1

ABSTRACT:

A method for characterizing an image where a number of test areas of predefined shape and size are located on the image. The color or the texture of the image over each of the test areas is quantified. The image can be characterized by statistical descriptions of the frequency distribution of color or texture of the test areas.

8 Claims, 12 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 7

---------- KWIC ---------

Brief Summary Text - BSTX (6):
Several processes have been proposed which attempt to preserve some of the spatial information that is discarded in the construction of a **color histogram**. Pass et.al in the paper entitled HISTOGRAM REFINEMENT FOR CONTENT BASED **IMAGE RETRIEVAL** proposed refining the **color histogram with color** coherence vectors. In this process the coherence of the color of a picture element in relation to that of other picture elements in a contiguous region is determined. Even though the number of picture elements of each **color is equal and, therefore, the color histograms** are identical for two images, differences between features in the images will mean that the numbers of picture elements of each color which are color coherent will vary. Color coherence vectors do embed some spatial information in the descriptors. Unfortunately, they require at least twice as much additional storage space as a traditional histogram.

Brief Summary Text - BSTX (7):
Rickman et al. in the paper entitled CONTENT-BASED **IMAGE RETRIEVAL** USING **COLOUR TUPLE HISTOGRAMS** proposed image characterization by construction of a **histogram of the color** hue at the vertices of randomly located triangular color

tuples. Since the vertices of the triangular tuples are spaced apart, some spatial information is retained. Unfortunately, it is difficult to determine the dominant color of an image from the color tuple data. Further, the retained spatial information is difficult to interpret in a normal sense, therefore making it difficult to use the information for indexing an image database.

Other Reference Publication - OREF (10):
Content-Based **Image Retrieval** Using **Color Tuple-Histograms**; Brunel University, Middlesex, UK; 1/96; pp. 2-7.

US-PAT-NO: 6584221

DOCUMENT-IDENTIFIER: US 6584221 B1

TITLE: Method for image retrieval with multiple regions of interest

DATE-ISSUED: June 24, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Moghaddam; Baback	Cambridge	MA	N/A	N/A
Biermann; Henning	New York	NY	N/A	N/A
Margaritis; Dimitris	Pittsburgh	PA	N/A	N/A

US-CL-CURRENT: 382/165, 382/199 , 382/305 , 707/6

ABSTRACT:

A method for representing an image in an image retrieval database first separates and filters images to extract color and texture features. The color and texture features of each image are partitioned into a plurality of blocks. A joint distribution of the color features and a joint distribution of the texture features are estimated for each block. The estimated joint distributions are stored in the database with each image to enable retrieval of the images by comparing the estimated joint

distributions.

17 Claims, 7 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 5

---------- KWIC ---------

Brief Summary Text - BSTX (5):

Most of the current content-based **image retrieval systems rely on global image** characteristics such as **color and texture histograms,** e.g., see Altavista's "Photofinder." While these simple global descriptors are fast and often do succeed in partially capturing the essence of the user's query, global descriptors often fail due to the lack of higher-level knowledge about what exactly was of interest to the user in the query image, i.e., user-defined content. Recently, there has been a gradual shift towards spatially-encoded image representations. Spatially-encoded representations range widely from fixed image partitioning, as in the "ImageRover," to highly local characterizations like the "color correlograms," please see Sclaroff et al. in "Imagerover: A content-based image browser for the world wide web," Proc. IEEE Workshop on Content-Based Access of Image and Video Libraries, June 1997, and Huang et al. in "Image indexing using color correlograms, "Proc. IEEE Conf. on Computer Vision and Pattern Recognition, 1997.

US-PAT-NO: 6351556

DOCUMENT-IDENTIFIER: US 6351556 B1

TITLE: Method for automatically comparing content of images for classification into events

DATE-ISSUED: February 26, 2002

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Loui; Alexander C.	Penfield	NY	N/A	N/A
Pavie; Eric S.	Rochester	NY	N/A	N/A

US-CL-CURRENT: 382/164, 382/168

ABSTRACT:

A method for comparing image content of first and second images, the method comprises the steps of extracting a portion of both the first and second images both of which portions are determined to include a main subject area of each image; dividing the main subject area of the images into a plurality of blocks; computing a **color histogram** for one block in each image; computing a histogram intersection value between the block of the first image and the block of the second image; and determining a first **threshold** value for the computed histogram intersection value that determines

similarity between the block in
the first image and the block in the second image.

18 Claims, 14 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 11

---------- KWIC ---------

Abstract Text - ABTX (1):
A method for comparing image content of first and second images, the method comprises the steps of extracting a portion of both the first and second images both of which portions are determined to include a main subject area of each image; dividing the main subject area of the images into a plurality of blocks; computing a **color histogram** for one block in each image; computing a histogram intersection value between the block of the first image and the block of the second image; and determining a first **threshold** value for the computed histogram intersection value that determines **similarity** between the block in the first image and the block in the second image.

Brief Summary Text - BSTX (4):
Pictorial images are often classified by the particular event, subject or the like for convenience of **retrieving, reviewing, and albuming of the images**. Typically, this has been achieved by manually segmenting the images, or by the

below-described automated method. The automated method includes grouping by color, shape or texture of the images for partitioning the images into groups of similar image characteristics.

Brief Summary Text - BSTX (8):

The present invention is directed to overcoming one or more of the problems set forth above. Briefly summarized, according to one aspect of the present invention, the invention resides in a method for comparing image content of first and second images, the method comprising the steps of: (a) extracting a portion of both the first and second images both of which portions are determined to include a main subject area of each image; (b) dividing the main subject area of the images into a plurality of blocks; (c) computing a **color histogram** for one block in each image; (d) computing a histogram intersection value between the block of the first image and the block of the second image; and (e) determining a first **threshold** value for the computed histogram intersection value that determines **similarity** between the block in the first image and the block in the second image.

US-PAT-NO: 5751286

DOCUMENT-IDENTIFIER: US 5751286 A

TITLE: Image query system and method

DATE-ISSUED: May 12, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Barber; Ronald Jason	San Jose	CA	N/A	N/A
Beitel; Bradley James	Woodside	CA	N/A	N/A
Equitz; William Robinson	Palo Alto	CA	N/A	N/A
Flickner; Myron Dale	San Jose	CA	N/A	N/A
Niblack; Carlton Wayne	San Jose	CA	N/A	N/A
Petkovic; Dragutin	Los Gatos	CA	N/A	N/A
Work; Thomas Randolph	San Fancisco	CA	N/A	N/A
Yanker; Peter Cornelius	Mountain View	CA	N/A	N/A

US-CL-CURRENT: 345/835, 345/838 , 345/968 , 382/209 , 382/220 , 382/305 , 707/4 , 707/6

ABSTRACT:

Images in an image database are searched in response to queries which include the visual characteristics of the images

such as colors, textures,
shapes, and sizes, as well as by textual tags
appended to the images. Queries
are constructed in an image query construction area
in response to values of
representations of the visual characteristics and
to locations of the
representations in the image query construction
area.

31 Claims, 18 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 13

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Brief Summary Text - BSTX (11):
The second case is when a color **image is specified, and similar images are to be retrieved**. A method for doing this is described in M. J. Swain, et al.
"Color Indexing", International Journal of Computer Vision, 7(1):11-32. 1991.
The method uses "**histogram intersection", in which a color histogram** is
computed for each image in the database, and a
corresponding **color histogram** is
computed for the query image. These histograms are
computed over a quantized
version of the available color space, giving, for
example, 256 bins in the
color histogram. A measure of similarity is
defined for two histograms, and a
query is run by computing the similarity between
the query image histogram and
the histogram of each image in the database.

Brief Summary Text - BSTX (12):

A more sophisticated method for **retrieving images** similar to a given image is given in Mikihiro Ioka. "A Method of Defining the Similarity of Images on the Basis of Color Information", Technical Resort RT-0030, IBM Tokyo Research Lab, 1989. Here, each image in the database (actually, the subimage of each image containing a single, dominant object the image) is partitioned into blocks, for example. 25 blocks. Within each block, the reduced bucket histogram,h, (say, 256 buckets) is computed. Given a query image or object, is also partitioned into the same number of blocks and the histograms computed. A similarity measure s(h.sub.query.sbsb.--.sub.image h.sub.database.sbsb.--.sub.item) is defined on the **color histograms** computed in the blocks, and the measure is extended to images as:

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US-PAT-NO: 6285995

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TITLE: Image retrieval system using a query image

DATE-ISSUED: September 4, 2001

INVENTOR-INFORMATION:

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US-CL-CURRENT: 707/3, 707/2 , 707/6

ABSTRACT:

An image retrieval system contains a database with a large number of images. The system retrieves images from the database that are similar to a query image entered by the user. The images in the database are grouped in clusters according to a similarity criterion so that mutually similar images reside in the same cluster. Each cluster has a cluster center which is representative for the images in it. A first step of the search to similar images selects the clusters that may contain images similar with the query image, by comparing the query image with the cluster centers of all clusters. A second step of the search compares the images in the selected clusters

with the query image in
order to determine their similarity with the query image.

10 Claims, 7 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 4

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Brief Summary Text - BSTX (5):

An **image retrieval** system and a method as described above, are known from the article "Tools and Techniques for Color **Image Retrieval**", John R. Smith and Shih-Fu Chang, Proc. SPIE--Int. Soc. Opt. Eng (USA), Vol. 2670, pp. 426-437. The **image retrieval system comprises a database with a large number of images**. A user searching for a particular **image specifies a query image as to how the retrieved image** or images should look like. Then the system compares the stored images with the query image and ranks the stored images according to their similarity with the query image. The ranking results are presented to the user who may **retrieve one or more of the images**. The comparison of the query image with a stored image to determine the similarity may be based on a number of features derived from the respective images. The image feature or features used for comparison are called a feature vector. The article describes the usage of a **color histogram** as

such a feature vector.
When using the RGB (Red, Green and Blue) representation of an image, a **color histogram is computed by quantizing the colors** within the image and counting the number of pixels of each color. To determine the similarity, a number of techniques are described to compare the two **color histograms** of the respective images. An example of such technique is the histogram intersection, where the similarity is the sum over all histogram bins of the minimal value of the pair of corresponding bins of the two histograms.

Brief Summary Text - BSTX (16):

An embodiment of the **image retrieval** system according to the invention is defined in claim 2. The similarity between images may be determined on the basis of their **color histograms**. The average of the respective histograms of a number of representative images of a cluster can advantageously be used as a representation for the whole cluster.

Detailed Description Text - DETX (3):

FIG. 1 schematically shows an **image retrieval** system according to the invention. The system 100 comprises a database 102 with a potentially large collection of candidate images. A purpose of the system is to **retrieve from the collection one or more images** that match the wishes of a user of the system. The system performs a content based search in the collection of the images, i.e. the content of an image is used as the

search or ranking
criterion, as opposed to systems that search on the basis of keywords in
annotation added to the images. The images in the database according to the
invention are grouped in clusters, of which
clusters 104, 106 and 108 are
shown. Images of a cluster are to a certain extent similar with each other.
For instance cluster 108 contains images 110, 112, 114 and 116 which are
according to a certain measure similar with each other. The content of an
image is represented in the system by a socalled feature vector, e.g. image 116
has a feature vector 118. In the system according to the invention, a **color histogram** of the image is used as feature vector
but the type of feature vector
is not essential to the invention and other measures expressing the
characteristics of the content of an image may be used. The feature vector may
be stored in the database with the image itself or at some other location in
the database, e.g. in a table with feature vectors of other images including a
reference to the image. A cluster has a cluster center representing the
contained images, e.g. cluster 108 has cluster center 120. In the system
according to the invention, the cluster center is the average of the **color histograms** of a number of representative images in the cluster. Another kind
of cluster center may be used, e.g. the feature vector of a single image which
is chosen as the representative image for all images in the cluster.

Detailed Description Text - DETX (6):

In an embodiment of the **image retrieval system according to the invention, the feature vector of an image is its color histogram**. The similarity measure between two images is calculated on the basis of the two **color histograms** of these images by determining the so-called histogram intersection. This technique is described in the article "Tools and Techniques for Color **Image Retrieval**", John R. Smith and Shih-Fu Chang, Proc. SPIE--Int. Soc. Opt. Eng (USA), Vol. 2670, pp. 426-437.

Detailed Description Text - DETX (20):

In a still further embodiment of the **image retrieval** system according to the invention, similarity coefficients are determined for each pair of corresponding bins of the two **color histograms** between which a similarity must be determined. Subsequently the obtained collection of similarity coefficients is treated as a probability distribution and the question as how similar the two histograms are, is then answered by analyzing this probability distribution. In this embodiment, the similarity coefficients are calculated using the following equation: ##EQU4##

Detailed Description Text - DETX (41):

In the embodiments of the **image retrieval** system described above, a single **color histogram** is made from the whole image. Because of this, the spatial

information from the image is lost and the comparison of two images reflects only global similarity. For example if a user enters a query **image with a sky at the top and sand at the bottom, the retrieved images** are expected to have a mix of blue and beige, but not necessarily a sky and sand. A desirable result for the **retrieved candidate images** would be images with blue at the top and beige at the bottom. In order to achieve this result, a further embodiment of the system according to the invention determines a **color histogram** for a number of respective regions of the query image and compares these determined histograms with histograms of corresponding regions of the candidate image.

The query image may be divided into regions using prefixed boundaries, e.g. the division of the image into a number of rectangles. Furthermore, the regions may be indicated manually by the user taking into account important objects in the query image. In this way, the user forces that a histogram is made for a region comprising the object of interest. The choice of the region size is important since it governs the emphasis that is given to local information. In one extreme, the whole image is considered as a single region so that only global information is used for the comparison. In the other extreme, the region size matches the individual pixels. In one of the further embodiments of the **retrieval system according to the invention, the images** are divided into 4.times.4 rectangular regions.

Detailed Description Text - DETX (61):

The **images in the database of the retrieval** system according to the invention are organized into clusters so as to allow a search to images similar with a given query image without the need of comparing all images with the query image. According to the invention, clusters of images are defined whereby similar images are grouped in a same cluster and a cluster center is defined for such cluster which is representative of the images in the cluster.

In an embodiment of the method of organizing the images in the database according to the invention, the images are clustered in a hierarchical way.

The number of images in the database is n and the similarities between all pairs of images is precomputed. The calculation of the similarities between the candidate images in the database is carried out using the same feature vector described above for the calculation of the similarity between the query image and a candidate image, namely the **color histograms** of the relevant images. However, a different type of feature vector may be used since the process of clustering the images in the database is not directly linked to the process of searching the database. The hierarchical clustering is carried out as follows:

Claims Text - CLTX (8):

2. An **image retrieval** system according to claim 1, in which at least one of

the cluster centers is represented by a **color histogram which is the average of respective color histograms** of a number of representative images in the particular cluster.

US-PAT-NO: 6621926

DOCUMENT-IDENTIFIER: US 6621926 B1

TITLE: Image retrieval system and method using image histogram

DATE-ISSUED: September 16, 2003

INVENTOR-INFORMATION:

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US-CL-CURRENT: 382/168, 382/305

ABSTRACT:

An **image retrieval system and method using an image** histogram for determining central points and dispersion values as well as quantity information of **color about respective histogram** bins, thereby using these as mapping information for **image retrieval**. The **image retrieval method using an image** histogram includes the following steps. A first step of computing an image histogram bin when an image is inputted, and accumulating values of x, y,

x.sup.2, y.sup.2 to compute central points and dispersion values. A second step of normalizing the respective central points and dispersion values through dividing these by size of whole image, and storing these. A third step of generating a value of model to be **retrieved by drawing a feature vector when a query image** is inputted, and computing the difference between the generated value of model and central points and dispersion values of an image histogram, count, and number of corresponding bins within the data stored in the second step. A fourth step of specifying a similarity value of an image using the values computed in the third step.

6 Claims, 3 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 3

---------- KWIC ---------

Abstract Text - ABTX (1):

An **image retrieval system and method using an image** histogram for determining central points and dispersion values as well as quantity information of **color about respective histogram** bins, thereby using these as mapping information for **image retrieval**. The **image retrieval method using an image** histogram includes the following steps. A first step of computing an image histogram bin when an image is inputted, and

accumulating values of x, y, x.sup.2, y.sup.2 to compute central points and dispersion values. A second step of normalizing the respective central points and dispersion values through dividing these by size of whole image, and storing these. A third step of generating a value of model to be **retrieved by drawing a feature vector when a query image** is inputted, and computing the difference between the generated value of model and central points and dispersion values of an image histogram, count, and number of corresponding bins within the data stored in the second step. A fourth step of specifying a similarity value of an image using the values computed in the third step.

Brief Summary Text - BSTX (2):

The present invention relates to an **image retrieval system and method using an image histogram, and, in particular, to an image retrieval system and method of using an image** histogram, for determining central points and dispersion values as well as quantity information of **color about respective histogram** bins, thereby using these as mapping information for **image retrieval**.

Brief Summary Text - BSTX (6):

This is because **color feature values of the histogram,** i.e., values of each bin show global feature information, and it is difficult to **retrieve an image** having correctly requested contents with only the global feature information.

That is, a global feature is advantageous for not being affected by rotation of the image or a slight change of position, but has a drawback of not containing any spatial information. Because of such characteristics of a global feature that does not contain spatial information, when retrieving with only color information, a false positive error in the retrieval result can occur.

Brief Summary Text - BSTX (11):

The disclosed embodiments of the present invention provide an **image retrieval system and method using an image** histogram for finding central points and dispersion values as well as quantity information of **color about respective histogram** bins, thereby using these as mapping information for **image retrieval**.

Brief Summary Text - BSTX (15):

Also, the disclosed embodiments provide a storage medium containing a program that executes steps, including the following steps. A first step is when an image is inputted, converting the image into color coordinate system, and normalizing it to reduce the feature of the converted values. A second step is computing **histogram color** bins from the normalized values in the first step, and accumulating x, y, x.sup.2, and y.sup.2, thereby computing central points and dispersion values. A third step is normalizing the respective computed central points and dispersion values by dividing with the size of

whole image, and storing it. A fourth step is when a query **image is inputted,** **generating a value of model to be retrieved** by drawing a feature vector, and then computing the difference between the generated value of model and the number, count of color values, and central points and dispersion values of bins corresponding to the stored data in the third step. And a fifth step is specifying the similarity values of an image using the computed values in the fourth step.

Detailed Description Text - DETX (24):

Although the present invention is illustrated and shown in connection with an **image retrieval** method using a **color histogram,** also in the case of a gray histogram, the **image retrieval** method using the mean value and the dispersion value, which are proposed in the present invention, can be applied.

Claims Text - CLTX (3):

3. The **image retrieval** method according to claim 2, wherein the first step further comprises: a first sub-step for converting the image into a color coordinate system when a color image is inputted, and normalizing this to reduce the feature of the converted value; and a second sub-step fpr computing a **color histogram** bin from the normalized value in the first sub-step.

Other Reference Publication - OREF (3):

Rickman et al. "Content-Based **Image Retrieval** Using **Colour Tuple Histograms**". SPIE V. 2670, p. 2-7, 1996.*

PUB-NO: WO009931605A1

DOCUMENT-IDENTIFIER: WO 9931605 A1

TITLE: IMAGE RETRIEVAL SYSTEM

PUBN-DATE: June 24, 1999

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ABSTRACT:

CHG DATE=19990803 STATUS=O>In an **image retrieval system, a database with a large number of images** is searched to find one or more images meeting the specification of a user. This specification is given in the form of a query image. The system determines the similarity between the query image and a particular image from the database by comparing the **color histograms** of the two images. The histograms are treated as statistical distributions and the similarity is determined on the basis of an information theoretic measure of the distributions. In a first embodiment, the similarity is determined using the Kullback informational divergence of the two histograms. In a second embodiment, the similarity is based on the entropy of the distribution of similarity coefficients of the two histograms is used.

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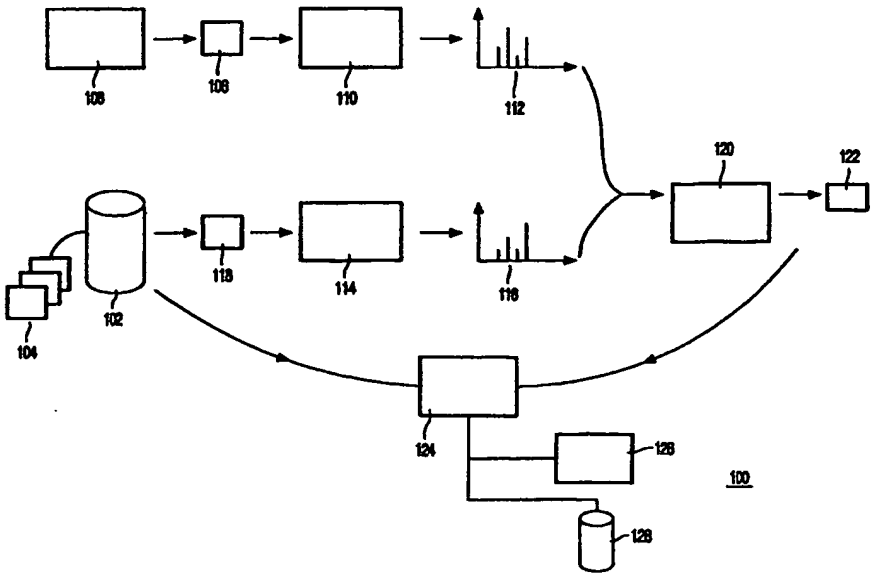

(57) Abstract

In an image retrieval system, a database with a large number of images is searched to find one or more images meeting the specification of a user. This specification is given in the form of a query image. The system determines the similarity between the query image and a particular image from the database by comparing the color histograms of the two images. The histograms are treated as statistical distributions and the similarity is determined on the basis of an information theoretic measure of the distributions. In a first embodiment, the similarity is determined using the Kullback informational divergence of the two histograms. In a second embodiment, the similarity is based on the entropy of the distribution of similarity coefficients of the two histograms is used.

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Image retrieval system.

BACKGROUND OF THE INVENTION

The invention relates to an image retrieval system which includes a database with candidate images, an entry unit for entering a query image, and a first histogram unit for deriving a first query color histogram from the query image.

A second histogram unit derives a first candidate color histogram from a particular candidate image. Also a determining unit determines a first similarity between the particular candidate image and the query image on the basis of the first candidate color histogram and the first query color histogram, and a retrieval unit retrieves of the particular candidate image.

The invention further relates to a method for determining a similarity between a candidate image and a query image.

A first step obtains the query image, a second step derives a query color histogram from the query image, a third step obtains a candidate color histogram from the candidate image, and a determining step determines the similarity between the particular candidate image and the query image on the basis of the candidate color histogram and the query color histogram.

Image retrieval systems are of importance for applications that involve large collections of images. Professional applications include broadcast stations where a piece of a video may be identified through a set of shots and where a shot of video is to be retrieved according to a given image. Also movie producers must be able to find back scenes from among a large number of scenes. Furthermore, art museums have large collections of images, from their paintings, photos and drawings, and must be able to retrieve images on the basis of some criterion. Consumer applications include maintaining collections of slides, photos and videos, from which the user must be able to find back items.

An image retrieval system and a method as described above, are known from the article "Tools and Techniques for Color Image Retrieval", John R. Smith and Shih-Fu Chang, Proc. SPIE - Int. Soc. Opt. Eng (USA), Vol. 2670, pp. 426-437. The image retrieval system includes a database with a large number of images. A user searching for a particular image specifies a query image as to how the retrieved image or images should look

like. Then the system compares the stored images with the query image and ranks the stored image according to their similarity with the query image. The ranking results are presented to the user who may retrieve one or more of the images. The comparison of the query image with a stored image to determine the similarity may be based on a number of features derived from the respective images. The article describes the usage of a color histogram as such a comparison feature. When using the RGB (Red, Green and Blue) representation of an image, a color histogram is computed by quantizing the colors within the image and counting the number of pixels of each color. To determine the similarity, a number of techniques are described to compare the two color histograms of the respective images. The histogram euclidean distance is a simple measure calculated by comparing identical bins in respective histograms. No cross-wise comparison is made between different bins which represent perceptually similar colors. Furthermore, techniques for determining a histogram intersection and techniques for determining a histogram quadratic distance are described. As an alternative to the histogram techniques, a comparison technique based on color sets is described. In this technique the color of a pixel is compared with a predetermined threshold. If the color is below the threshold, the pixel does not become a member of the set and otherwise it does become a member. A disadvantage is that a large number of pixels, all below the threshold, will not contribute in the comparison in any way. Furthermore, there is no discrimination between values above the threshold. The prior art techniques for determining the similarity between the candidate image and the query image are complex to execute and/or are occasionally not adequate enough.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an image retrieval system of the kind set forth with an improved mechanism for determining the similarity between the candidate image and the query image. This object is achieved in an image retrieval system having the determining unit arranged to determine the first similarity on the basis of information conveyed by the first candidate color histogram in response to information requested by the first query color histogram. Determining the similarity between the respective images using an information theoretic measure is superior to the known techniques. The image retrieval system according to the invention is better able to establish the similarity between the query image and the images in the database. So, the image retrieval system according to the invention is superior in finding similar images and in avoiding images that are not similar enough. Furthermore, the calculation of the information

theoretic measure requires less computational effort than the known techniques.

An embodiment of the image retrieval system according to the invention uses a Kullback informational divergence. The Kullback informational divergence is a measure for determining how different one statistical distribution is from another statistical distribution. The inventor has realized that a color histogram can be treated as a statistical distribution and that the Kullback informational divergence can be applied for comparing the candidate color histogram with the query color histogram. Experiments have shown that retrieval of images on the basis of a similarity obtained from applying the Kullback informational divergence on the respective color histograms gives very good results. Furthermore, the calculation of the Kullback informational divergence requires less computational effort than the known techniques, which is very important since a large number of candidate images may need to be compared with the query image.

Another embodiment of the image retrieval system also considers entropy of similarity coefficients. By determining the entropy of the distribution of the similarity coefficients, an indication of the flatness of this distribution is obtained. Since a particular similarity coefficient indicates the similarity between the candidate color histogram and the query color histogram for the particular bin, the obtained flatness is a measure for the similarity of the candidate color histogram and the query color histogram over all bins. Experiments have shown that retrieval of images on the basis of a similarity based on the entropy measure gives very good results. Furthermore, the calculation of the entropy requires less computational effort than the known techniques, which is very important since a large number of candidate images may need to be compared with the query image.

A further embodiment of the image retrieval system according to the invention compares two color histograms of respective regions of the candidate image with two color histograms of corresponding regions of the query image, the spatial information in the respective images being employed when determining the similarity. This improves the accuracy of determining the similarity between the candidate image and the query image and a better discrimination among the images in the database can be achieved.

A still further embodiment of the image retrieval system according to the invention uses median statistics for determining the overall similarity from the similarities of the regions. This is better than simply averaging the similarities of the regions. The median statistics suppress the effect of large outliers which would negatively influence the perceived similarity of the candidate image and the query image.

An embodiment of the image retrieval system according to the invention

allows the user to compose the query image. Such a query image can be completely specified according to the user's wishes. The user may compose the query image by taking samples from images available in the system or may sketch an image from scratch.

It is a further object of the invention to provide a method of the kind set forth with an improved step for determining the similarity between the candidate image and the query image on the basis of the candidate color histogram and the query color histogram. This object is achieved according to the invention in a method that is characterized in that the determining step includes determining the similarity on the basis of information conveyed by the candidate color histogram in response to information requested by the query color histogram. By determining the similarity between the respective images through an information theoretic measure better results are obtained. When this method is applied for searching an image, a better discrimination among the searched images with respect to the query image can be obtained. A further advantage of the method according to the invention is that the calculation of the information theoretic measure requires less computational effort than the known techniques, which is particularly important for searching through large collections of images.

Further advantageous embodiments of the invention are discuseed below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and its attendant advantages will be further elucidated with the aid of exemplary embodiments and the accompanying schematic drawings, whereby:

Figure 1 schematically shows an image retrieval system according to the invention,

Figure 2 schematically shows an image retrieval system according to the invention with multiple color histograms per image,

Figure 3 shows the process of determining a color histogram from an image,

Figure 4 shows the most important components of the image retrieval system according to the invention, and

Figure 5 shows an overview of the method according to the invention.

Corresponding features in the various Figures are denoted by the same reference symbols.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 schematically shows an image retrieval system according to the invention. The system 100 includes a database 102 with a potentially large collection 104 of images. A purpose of such a system is to retrieve from the collection one or more images that match the wishes of a user of the system. Those wishes are specified via a query image 106, which the user can enter into the system via entry means 108. The entry unit may allow the user to compose the query image from a number of existing images or to create the query image from scratch. The system compares the query image with the candidate images in the database and determines for each candidate image how similar it is to the query image. The system ranks the candidate images according to the established similarity. The system 100 compares images on the basis of their color histogram. To this end, the system includes first histogram unit 110 to determine a query color histogram 112 from the query image 106. The process of determining a color histogram from an image is explained in Figure 3 below. The system also includes second histogram unit 114 to determine a candidate color histogram 116 from a particular candidate image 118. The first histogram unit and the second histogram unit may be integrated into one histogram means, which can act on the query image for generating the query color histogram and on the particular candidate image for generating the candidate color histogram respectively. The system further includes determining unit 120 to determine a similarity 122 on the basis of the query color histogram 112 and the candidate color histogram 116. Based on the similarity, the system presents a ranking of the candidate image on a display 126. The user may select an image from this ranking which is retrieved from the database via retrieval means 124 for further processing. This further processing may include temporarily storing the image in a file 128 for further selection. This may be implemented as that the system retrieves a number of candidate images and stores these in the file 128, from where the user makes a final selection as to which image is desired. In such a way of working, the system makes a first selection from the large collection in the database 102 and the user selects the image or images from the much smaller collection in file 128.

In a first embodiment of the image retrieval system according to the invention, the two color histograms between which a similarity must be determined are treated as two probability distributions. The question as how similar the two histograms are, can then be answered by measuring how different the one probability distribution is from the other. This difference between two statistical distributions is called informational divergence or Kullback informational divergence and is calculated with the following equation:

$$D(Q \| P) = \sum_{x \in X} Q(x) \log \frac{Q(x)}{P(x)} \quad (1)$$

In which:

Q(x) is the normalized query color histogram,

P(x) is the normalized candidate color histogram, and

D(Q ‖ P) is the Kullback informational divergence.

A more detailed discussion on the Kullback informational divergence is presented in the textbook "Information Theory: Coding Theorems for Discrete Memoryless Systems", I. Csizar and J. Korner, Akademia Kiado, Budapest, 1981, pages 19-22.

Equation (1) can be rewritten to

$$D(Q \| P) = \sum_{x \in X} Q(x) \log Q(x) - \sum_{x \in X} Q(x) \log P(x) \quad (2)$$

The first term in equation (2) is the entropy of distribution Q(x) and is fully determined by the contents of the query. Therefore this first term is the same for all candidate images of the database and need not be considered when ranking the candidate images with respect to similarity to the query image. According to this first embodiment of the image retrieval system according to the invention, the similarity between the candidate image and the query image is therefore calculated with the following equation:

$$S_K(Q,P) = \sum_{x \in X} Q(x) \log P(x) \quad (3)$$

In which:

$S_K(Q,P)$ is the similarity between the candidate image and the query image,

Q(x) is the normalized query color histogram, and

P(x) is the normalized candidate color histogram.

The value of $S_K(O,P)$ is used to rank the candidate image with respect to their similarity with the query image. A relatively large value indicates that two images are similar and a relatively low value indicates that two images are dissimilar.

In a second embodiment of the image retrieval system according to the invention, similarity coefficients are determined for each pair of corresponding bins of the two color histograms between which a similarity must be determined. Subsequently the obtained collection of similarity coefficients is treated as a probability distribution and the question as how similar the two histograms are, is then answered by analyzing this probability distribution. In this embodiment, the similarity coefficients are calculated using the following equation:

$$r_i(P,Q) = \frac{\min(p_i,q_i)}{\max(p_i,q_i)} \qquad (4)$$

In which:

$r_i(P,Q)$ is the similarity coefficient between bin i of the candidate color histogram and bin i of the query color histogram,

p_i is the number of pixels in bin i of the candidate color histogram, and

q_i is the number of pixels in bin i of the query color histogram.

Especially in cases where the candidate images in the database have significantly different color histograms, comparison on the basis of the similarity coefficients as such is not sufficient. Therefore the distribution of the similarity coefficients over the bins is analyzed. First the distribution is normalized using the following equation:

$$s_i = \frac{r_i}{\sum_{j=0}^{N-1} r_j} \; ; \; i \in [0,N-1] \qquad (5)$$

In which:

s_i is an element of the normalized probability distribution S,

r_i is calculated using equation (4), and

N is the number of bins.

The flatness of the distribution S is used in addition to the similarity coefficients themselves for determining the similarity between the candidate color histogram and the query color histogram. A flat distribution indicates a good overall match, while one with few peaks indicates a good match over a few bins. The level of flatness of the

probability distribution S is measured by calculating its entropy using the following equation:

$$H(S) = -\sum_{j=0}^{N-1} s_j \log(s_j) \quad (6)$$

In which:

H(S) is the entropy of distribution S,

s_j is an element of the distribution S, calculated using equation (5), and

N is the number of bins.

H(S) lies in the range [0,log(N)]. H(S) = log(N) indicates that the similarity coefficients of all bins are equal, i.e. $r_i = r_j$, i,j element of [0,N-1]. The value H(S) = 0 indicates that there is at most one histogram bin over which the histograms P and Q are similar. In this embodiment of the image retrieval system according to the invention, the similarity is obtained by combining the entropy H(S) and the sum of the similarity coefficients using the following equation:

$$S_E(P,Q) = H(S) \times \sum_{j=0}^{N-1} r_j \quad (7)$$

In which:

$S_E(Q,P)$ is the similarity between the candidate image and the query image,

H(S) is the entropy according to equation (6), and

r_j is the similarity coefficient according to equation (4).

$S_E(Q,P)$ lies in the range [0,Nlog(N)]. A larger value of $S_E(Q,P)$ indicates a higher similarity between the candidate color histogram P and the query color histogram Q. If $S_E(Q,P) = 0$, P and Q are very dissimilar. If $S_E(Q,P) = N\log(N)$, P and Q are identical.

In the embodiments of the image retrieval system described above, a single color histogram is made from the whole image. Because of this, the spatial information from the image is lost and the comparison of two images reflects only global similarity. For example if a user enters a query image with a sky at the top and sand at the bottom, the retrieved images are expected to have a mix of blue and beige, but not necessarily a sky and sand. A desirable result for the retrieved candidate images would be images with blue at the top and beige at the bottom. In order to achieve this result, a further

embodiment of the system according to the invention determines a color histogram for a number of respective regions of the query image and compares these determined histograms with histograms of corresponding regions of the candidate image. The query image may be divided into regions using pre-fixed boundaries, e.g. the division of the image into a number of rectangles. Furthermore, the regions may be indicated manually by the user taking into account important objects in the query image. In this way, the user forces that a histogram is made for a region comprising the object of interest. The choice of the region size is important since it governs the emphasis that is given to local information. In one extreme, the whole image is considered as a single region so that only global information is used for the comparison. In the other extreme, the region size matches the individual pixels. In one of the further embodiments of the retrieval system according to the invention, the images are divided into 4 x 4 rectangular regions.

Figure 2 schematically shows an image retrieval system according to the invention with multiple color histograms per image. In this system, the first histogram means 110 determine a first query color histogram 202 of a first region of the query image 106 and a second query color histogram 204 of a second region of the query image 106. In the same way, the second histogram means 114 determine a first candidate color histogram 206 of a first region of the particular candidate image 118 and a second candidate color histogram 208 of a second region of the particular candidate image 118. The example in Figure 2 shows 2 color histograms per image, but this is mainly for the purpose of illustration since in practice the system will have more than 2 color histograms per image, for instance 8 or 16. In a subsequent step the determining means 120 of the system makes multiple pair-wise comparisons of the respective color histograms and determines a similarity for each comparison. These individual similarities are combined into one overall similarity indicating how similar the candidate image and the query image are, taking into account the local information. The determining means determine a first similarity 210 on the basis of the first query color histogram 202 and the first candidate color histogram 206. This first similarity 210 indicates how similar is the first region of the query image 106 to the first region of the candidate image 118. The determining means further determine a second similarity 212 on the basis of the second query color histogram 204 and the second candidate color histogram 208. This second similarity 212 indicates how similar is the second region of the query image 106 to the second region of the candidate image 118. Subsequently, the determining means determine an overall similarity 214 on the basis of the first similarity 210 and the second similarity 212. This overall similarity 214 indicates the similarity between the query

image 106 and the candidate image as a whole, taking into account the local information captured through the division in regions. The overall similarity 214 is used to rank the candidate images stored in the database 102.

Combining the region similarities corresponding to the respective regions of the query image and the candidate image into an overall similarity should avoid that too much emphasis is put on any one the region similarities. Therefore, the further embodiments of the system according to the invention use the median of the region similarities as a measure of the similarity for the whole image. In the further embodiment of the system using the Kullback informational divergence, the overall similarity between the candidate image and the query image, based on similarities of respective regions of the images is calculating according to the following equation:

$$\hat{S}_K(I_Q,I_P) = \underset{(k,l\in[0,M-1])}{Median}\{S_k(Q_{kl},P_{kl})\} \quad (8)$$

In which:

I_Q is the query image,

I_P is the particular candidate image,

$\hat{S}_K(I_Q, I_P)$ is the overall similarity between image P and Q,

Q_{kl} is the color histogram of region k,l of the query image,

P_{kl} is the color histogram of region k,l of the particular candidate image,

$S_K(Q_{kl}, P_{kl})$ is the similarity between region k,l of the candidate image and region k,l of the query image, based on the Kullback informational divergence according to equation (3), and M is the number of regions into which the image is divided in the horizontal and in the vertical direction.

The median function sorts the individual region similarities and selects the middle one to be the overall similarity.

In the further embodiment of the system using the entropy measure, the overall similarity between the candidate image and the query image, based on similarities of respective regions of the images is calculated according to the following equation:

$$\hat{S}_E(I_Q,I_P) = \underset{(k,l\in[0,M-1])}{Median}\{S_E(Q_{kl},P_{kl})\} \quad (9)$$

In which:

I_Q is the query image,

I_P is the particular candidate image,

$\hat{S}_E(I_Q, I_P)$ is the overall similarity between image P and Q,

Q_{kl} is the color histogram of region k,l of the query image,

P_{kl} is the color histogram of region k,l of the particular candidate image,

$S_E(Q_{kl}, P_{kl})$ is the similarity between region k,l of the candidate image and region k,l of the query image, based on the entropy measure according to equation (7), and

M is the number of regions into which the image is divided in the horizontal and in the vertical direction.

Figure 3 shows the process of determining a color histogram from an image. Color images in the system according to the invention are represented by the three color components of the RGB (Red, Green and Blue) color space. However, the invention can also be applied for images represented in another color space. A histogram is constructed by independently quantizing the Red component 302, the Green component 304 and the Blue component 306 of every pixel. This color quantization results in the representation of the entire color spectrum by a smaller set of discrete values referred to as quantization levels. This is a many-to-one mapping and the set of colors mapped to the same quantization level forms a quantization cell. The number of quantization levels is referred to as q_L. A histogram is built by uniformly quantizing the R, G and B components of every pixel, mapping the three quantized values 308, 310 and 312 to a composite color value 314, and incrementing the corresponding histogram bin. The quantized color components r, g and b are mapped to a 1-dimensional composite space using the following equation:

$$C_c(r,g,b) = \alpha_r \times r + \alpha_g \times g + \alpha_b \times b \qquad (10)$$

In which:

C_c is the composite color value,

α_r is the mapping coefficient for the R component,

α_g is the mapping coefficient for the G component,

α_b is the mapping coefficient for the B component,

Each quantized component r, g and b takes a value between 0 and $(q_L - 1)$ and there are $(q_L)^3$ quantized possible combinations. To ensure a unique mapping from the R,

G and B components to a composite color value the following scheme is chosen for the mapping coefficients: $\alpha_r = (q_L)^2$, $\alpha_g = (q_L)^1$, and $\alpha_b = (q_L)^0 = 1$. After each pixel has been mapped to a composite color value and the histogram bins have been filled with the number of corresponding appearances, the histogram is normalized for further use. Normalization comes down to dividing the number of pixels in each bin by the total number of pixels in all bins. After normalization, a bin contains a number representing the fraction of the pixels belonging to that bin rather than a number representing the sum of those pixels. Throughout this document, a reference to a color histogram is generally to be considered as a reference to a normalized color histogram.

In the further embodiments of the image retrieval system according to the invention, multiple histograms are generated from a single image. Each of the multiple histogram is a histogram of a specific region of the image. In the example of Figure 3, 4 histograms, 316, 318, 320 and 322, are generated for the four indicated regions of the image.

Figure 4 shows the most important components of the image retrieval system according to the invention. The image retrieval system 400 is implemented according to a known architecture and can be realized on a general purpose computer. The image retrieval system has a processor 402 for carrying out instructions of an application program loaded into working memory 404. The image retrieval system further has an interface 406 for communication with peripheral devices. There is a bus 408 for exchange of commands and data between the various components of the system. The peripherals of the image retrieval system include a storage medium 410 containing the executable programs, the database with images, and various other data. The storage medium 410 can be realized as various separate devices, potentially of different kind of storage device. Application of the invention is not restricted by the type of device and storage devices which can be used include optical disc, magnetic disc, tape, chip card, solid state or some combination of these devices. Furthermore, some of the data may be at a remote location and the image retrieval system may be connected to such a location by a network via connection 411. The peripherals of the image retrieval system further include a display 412 on which the system displays, amongst others, the query image and the candidate images. Furthermore the peripherals preferably include a selection device 414 and a pointing device 416 with which the user can move a cursor on the display. Devices 414 and 416 can be integrated into one selecting means 418 like a computer mouse with one or more selection buttons. However, other devices like a track ball, graphic tablet, joystick, or touch sensitive display are also

possible. In order to carry out the various tasks, a number of software modules are loaded into the working memory 404, among which are modules constituting: entry means 108, first histogram means 110, second histogram means 114, determining means 120 and retrieval means 124. Furthermore, the working memory 404 has memory space 420 for temporarily storing input and output data and intermediate results, like the respective histograms and the determined similarity.

Figure 5 shows an overview of the method according to the invention. In a first step 502, a query image is obtained containing the wishes of the user. This image may be composed from existing images or may be sketched by the user, possibly on the basis of an existing image. Then in a second step 504, a query color histogram of the query image is determined. This query color histogram will be used in comparing the query image with candidate images from a database. In a third step 506, a candidate color histogram of one of such candidate images is obtained. Preferably this candidate color histogram has been prepared in advance at the moment the candidate image had been stored in the database. Then obtaining the candidate color histogram now, comes down to simply retrieving the histogram. Alternatively, the candidate color histogram could be created at this instant, i.e. at the time when it is needed. When the candidate color histogram has been obtained, the similarity between the query image and the candidate image is determined in a determining step 508. If in a comparison step 510 it is ascertained that the images are similar enough, the particular candidate image is retrieved from the database in retrieval step 512. The particular candidate image may be directly presented to the user or may be temporarily stored in a file for later inspection. Then in step 514 it is determined whether all candidates images in the database have been dealt with. If this is not the case, a candidate color histogram of a next candidate image is obtained in step 506 and the process is repeated for this next candidate image.

CLAIMS:

1. An image retrieval system comprising:

- a database with candidate images,
- entry means for entering a query image,
- first histogram means for deriving a first query color histogram from the query image,
- second histogram means for deriving a first candidate color histogram from a particular candidate image,
- determining means for determining a first similarity between the particular candidate image and the query image on the basis of the first candidate color histogram and the first query color histogram, and
- retrieval means for retrieval of the particular candidate image,

the determining means being arranged to determine the first similarity on the basis of information conveyed by the first candidate color histogram in response to information requested by the first query color histogram.

2. An image retrieval system according to Claim 1, wherein the determining means are arranged to determine the first similarity on the basis of the Kullback informational divergence between the first candidate color histogram and the first query color histogram.

3. An image retrieval system according to Claim 2, wherein the determining means are arranged to determine the first similarity according to the following equation:

$$S_K(Q,P) = \sum_{x \in X} Q(x) \log P(x)$$

4. An image retrieval system according to Claim 1, wherein the determining means are arranged to determine the first similarity on the basis of the entropy of the distribution of similarity coefficients over the bins of the first candidate color histogram and of the first query color histogram.

5. An image retrieval system according to Claim 4, wherein the determining

means are arranged to determine the first similarity according to the following equation:

$$S_E(P,Q) = H(S) \; x \sum_{j=0}^{N-1} r_j$$

6. An image retrieval system according to Claim 1, wherein

- the first histogram means are arranged to derive the first query color histogram from a first region of the query image and to derive a second query color histogram from a second region of the query image,
- the second histogram means are arranged to derive the first candidate color histogram from a first region of the candidate image and to derive a second candidate color histogram from a second region of the candidate image, and
- the determining means are arranged to determine a second similarity between the particular candidate image and the query image on the basis of the second query color histogram and the second candidate color histogram and to determine an overall similarity between the particular candidate image and the query image on the basis of the first similarity and the second similarity.

7. An image retrieval system according to Claim 6, wherein the determining means are arranged to determine the overall similarity using median statistics for combining the first similarity and the second similarity.

8. An image retrieval system according to Claim 1, wherein the entry means are arranged to enable the user to compose the query image.

9. A method for determining a similarity between a candidate image and a query image, the method comprising the following steps:

- a first step for obtaining the query image,
- a second step for deriving a query color histogram from the query image,
- a third step for obtaining a candidate color histogram from the candidate image, and
- a determining step for determining the similarity between the particular candidate image and the query image on the basis of the candidate color histogram and the query color histogram,

the determining step including determining the similarity on the basis of information conveyed by the candidate color histogram in response to information requested by the query

color histogram.

10. A method according to Claim 10, wherein the determining step includes determining the similarity on the basis of the Kullback informational divergence between the candidate color histogram and the query color histogram.

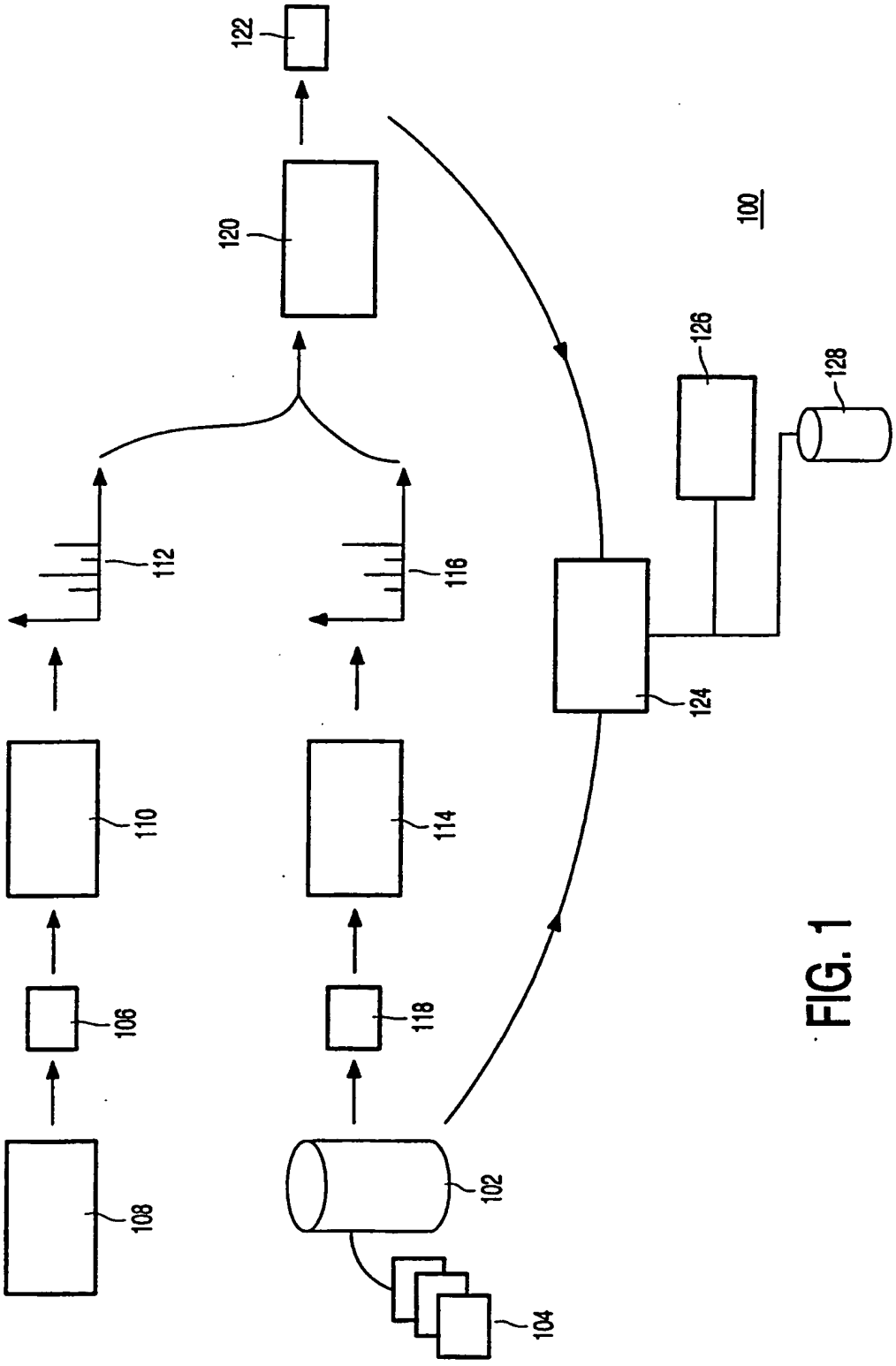
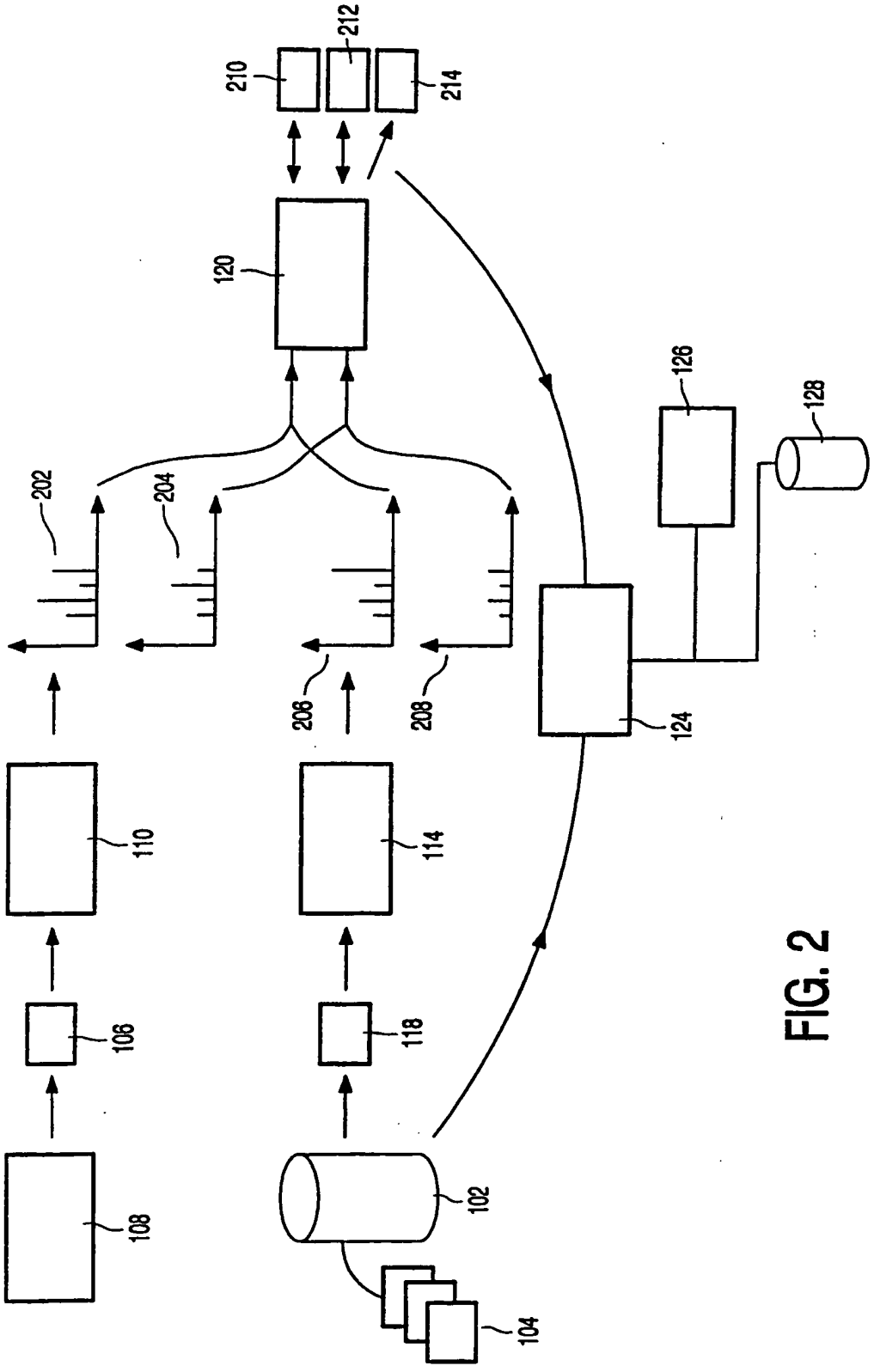


FIG. 1


210
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102
104

FIG. 2

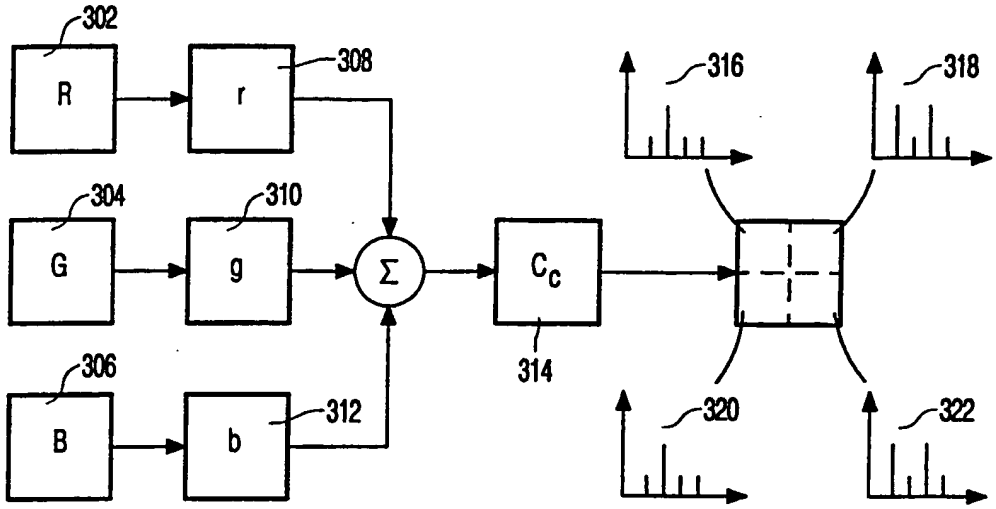
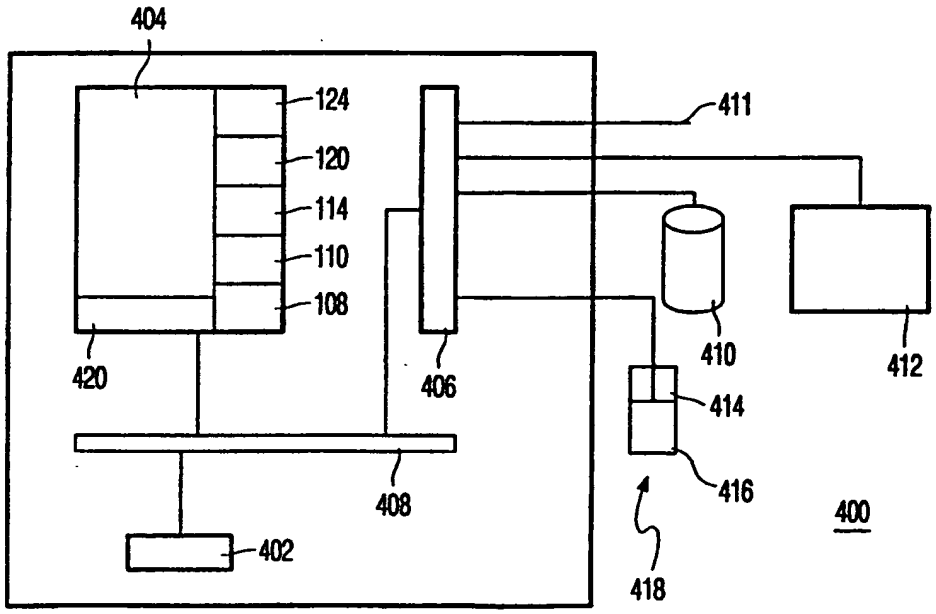

302
R
308
r
304
G
310
g
306
B
312
b
Σ
C_c
314
316
318
320
322

FIG. 3


404
124
120
114
110
108
420
406
411
410
412
414
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418
408
402
400

FIG. 4

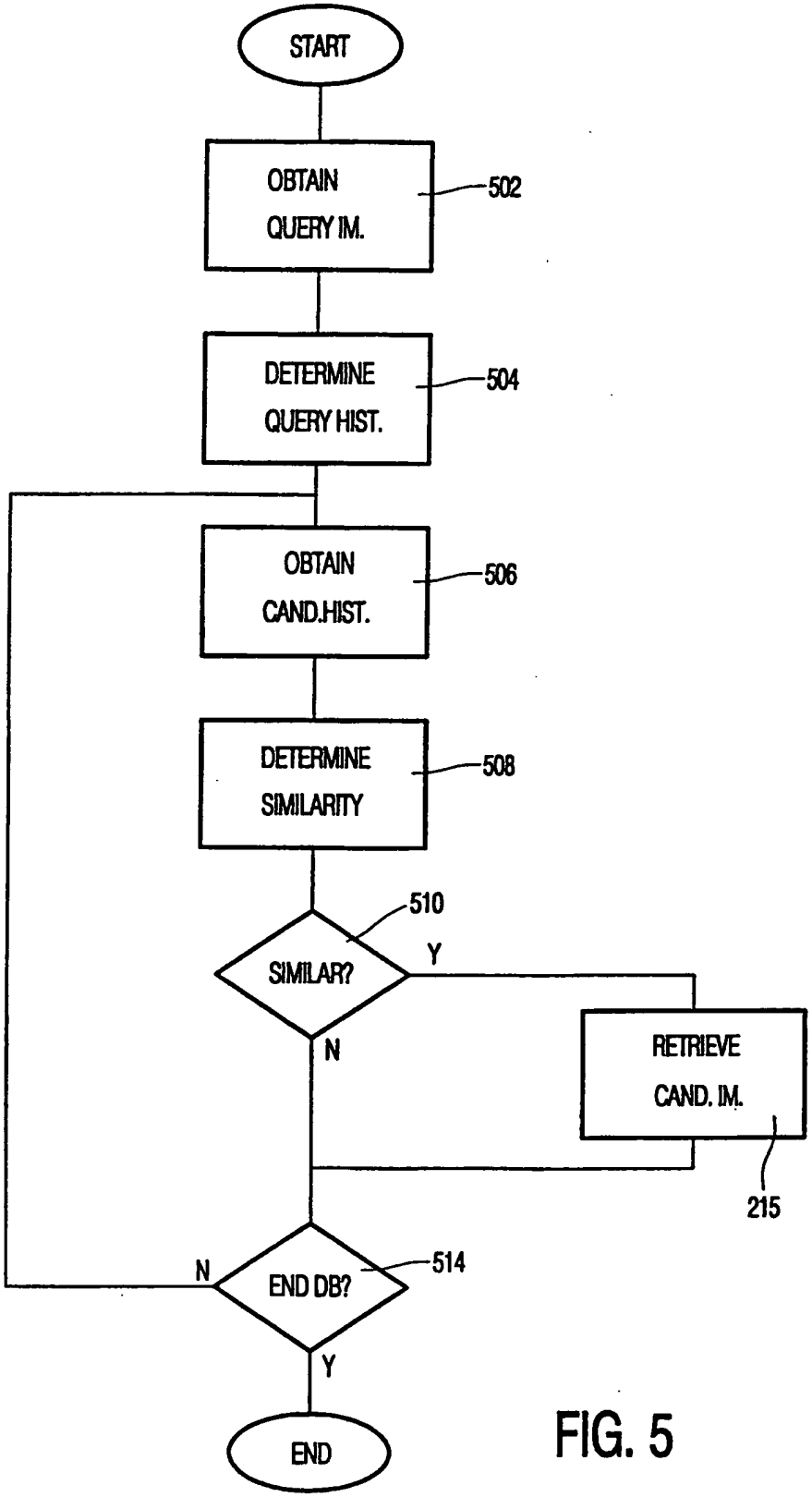
START
OBTAIN QUERY IM.
502
DETERMINE QUERY HIST.
504
OBTAIN CAND.HIST.
506
DETERMINE SIMILARITY
508
510
SIMILAR?
Y
N
RETRIEVE CAND. IM.
215
N
END DB?
514
Y
END

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 98/01983

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G06F 17/30, G06K 9/68 // G 06 T 5/40
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G06F, G06K, G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CHEN, Jau-Yuen et al. "Multiscale Branch and Bound Image Database Search". In: Proceedings of the SPIE, San Jose, CA, 13-14 February 1997, Vol. 3022, ISBN 0-8194-2433-1, pages 133 to 144.	1-10
A	US 5048095 A (B. BHANU ET AL.), 10 Sept 1991 (10.09.91), column 7, line 21 - line 50	1-10
A	EP 0627726 A1 (NEC CORPORATION), 7 December 1994 (07.12.94), page 12, line 29 - line 47	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 May 1999	20 -05- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Malin Keijser Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

03/05/99

International application No.
PCT/IB 98/01983

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5048095 A	10/09/91	GB 2242598 A,B	02/10/91
EP 0627726 A1	07/12/94	CA 2124906 A	04/12/94
		JP 2522154 B	07/08/96
		JP 6348292 A	22/12/94

PAT-NO: JP411102439A

DOCUMENT-IDENTIFIER: JP 11102439 A

TITLE: METHOD AND DEVICE FOR RETRIEVING OBJECT IN IMAGE

PUBN-DATE: April 13, 1999

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APPL-NO: JP09262979

APPL-DATE: September 29, 1997

INT-CL (IPC): G06T007/00, G06T001/00

ABSTRACT:

PROBLEM TO BE SOLVED: To provide a method and a

device which can retrieve an object in an image with high accuracy.

SOLUTION: First, a timewise distribution of colors in a **retrieval key image** of an object is examined and it is decomposed into plural parts (1). Next, the **retrieval key image and a retrieval object image** are divided into blocks, and a **color histogram** for each block is calculated (2). Then, a part **image that shows the certainty in which each point in the retrieval key image and the retrieval object image** belonging to each of the parts is produced by **color histogram matching that reflects color** similarity (3). An adjacent histogram that represents arrangement relation of the parts is calculated by using the part image (4). Next, the certainty value of the part **image which is created from the retrieval object image** is updated by using an adjacent histogram, thus the effects of background is reduced (5). Finally, the existence of the object in the **retrieval object image** is discriminated (7) by collating the adjacent histogram (6) that is calculated from the **retrieval key image and a part image of the updated retrieval object image**.

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1/00			15/62	３８０
			15/70	３２５

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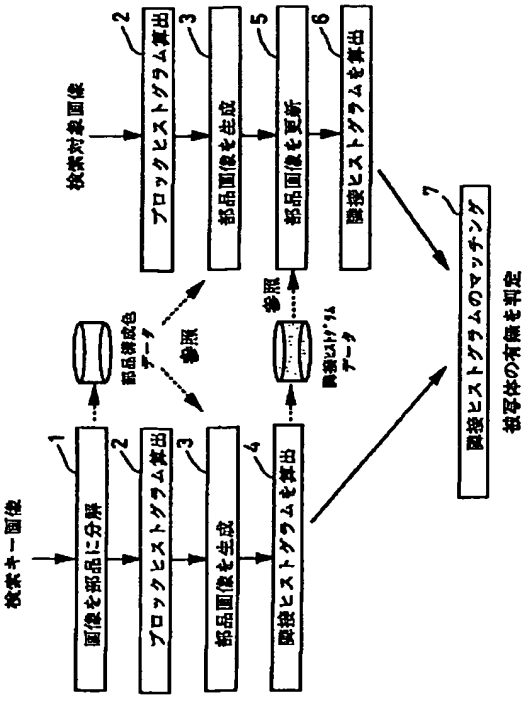
(54)【発明の名称】　画像中被写体検索方法および装置

(57)【要約】
【課題】　高精度で検索可能な画像中被写体検索方法及び装置を提供する。
【解決手段】　まず、被写体の検索キー画像中の色の空間的な分布を調べ、複数の部品に分解する（１）。次に、検索キー画像及び検索対象画像をブロック分割し、各ブロック内の色ヒストグラムを算出する（２）。次に、色の類似性を反映した色ヒストグラムマッチングにより、検索キー画像及び検索対象画像中の各点が前記各々の部品に属する確からしさを示す部品画像を生成する（３）。次に、部品画像を用いて前記部品の配置関係を表す隣接ヒストグラムを算出する（４）。次に、この隣接ヒストグラムを用いて前記検索対象画像から生成された部品画像の確からしさの値を更新し、背景の影響を削減する（５）。最後に、検索キー画像及び更新された検索対象画像の部品画像から算出した隣接ヒストグラム（６）を照合することで、前記検索対象画像中の被写体の有無を判定する（７）。



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【特許請求の範囲】
【請求項1】　被写体の例示画像を検索キー画像として与えることにより、検索対象となる画像データおよび映像データから、前記被写体が写っている画像や映像の一部分を提示する画像検索方法であって、
前記検索キー画像中の色の分布を調べることにより、該検索キー画像を複数の部品に分解する第1の過程と、
前記検索キー画像および検索対象画像を複数の粗さのブロックに分割し、各ブロック毎に色ヒストグラムを算出する第2の過程と、
前記検索キー画像から分解されて抽出された各々の部品と前記分割された各ブロック内の色ヒストグラムを色の類似性を考慮して照合し、画像中の各点が各々の部品に属する確からしさを示す画像である部品画像を生成する第3の過程と、
前記検索キー画像から生成された部品画像を用いて、該検索キー画像中の部品の配置関係をヒストグラム化した隣接ヒストグラムを算出する第4の過程と、
前記算出された隣接ヒストグラムを用い、前記検索対象画像から生成された部品画像において、前記検索キー画像中の部品の配置関係と整合する部分の値を上昇させ、一方該検索キー画像中の部品の配置関係と整合しない部分の値を減少させることにより、各部品に属する確からしさの値を更新して背景部分から誤って生成された部品候補領域の影響を削減する第5の過程と、
前記検索キー画像と同様に、前記更新された検索対象画像の部品画像から隣接ヒストグラムを生成する第6の過程と、
前記検索キー画像および検索対象画像の隣接ヒストグラムを照合するすることにより、検索対象画像中の被写体の有無を判定する第7の過程と、
を有することを特徴とする画像中被写体検索方法。
【請求項2】　被写体の例示画像で与えられた検索キー画像中の色の空間的な分布を調べることにより、該例示画像を複数の部品に分解する第1の手段と、
前記検索キー画像および検索対象画像を複数の粗さにブロック分割し、各ブロック内の色ヒストグラムを算出する第2の手段と、
色の類似性を反映した前記色ヒストグラムのマッチングにより、前記検索キー画像および検索対象画像中の各点が前記分解された各々の部品に属する確からしさを示す部品画像を生成する第3の手段と、
前記検索キー画像から生成された部品画像を用いて前記部品の配置関係をヒストグラム化した隣接ヒストグラムを算出する第4の手段と、
前記検索キー画像から算出された隣接ヒストグラムを用いて前記検索対象画像から生成された部品画像における前記各々の部品に属する確からしさの値を更新して背景の影響を削減する第5の手段と、
前記更新された検索対象画像の部品画像から隣接ヒストグラムを算出する第6の手段と、

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前記検索キー画像および前記更新された検索対象画像の部品画像から算出された隣接ヒストグラムを照合することにより、前記検索対象画像中の被写体の有無を判定する第7の手段と、
を有することを特徴とする画像中被写体検索装置。
【発明の詳細な説明】
【0001】
【発明の属する技術分野】本発明は、画像や映像に対して検索を行うデータベースシステム、および画像や映像の整理や属性情報の付与を行う画像編集システムおよび映像編集システムにおいて、画像や映像を検索キーとして所望の映像や画像を検索するための画像処理方法および装置に関する。
【0002】
【従来の技術】これまでに提案されている被写体検索技術は3つに分類することができる。
【0003】1つめは、色の情報のみに注目し、色のヒストグラムマッチングにより被写体の探索を行う手法である。しかし、空間的な情報を用いていないため、被写体以外にも色の似ている物体や領域を誤抽出してしまうという問題がある。
【0004】2つめは、画像を一定サイズにブロック分割し、ブロックの色の隣接関係を用いて被写体の有無を判定する手法である。しかし、適切なブロックのサイズが被写体のサイズに依存するため、被写体のサイズが不定の場合には不安定になるという問題がある。また対象の記述が粗すぎるため検索の精度は不十分である。
【0005】3つめは、被写体を部品化して部品間の配置関係を検証することにより被写体の有無を検知する方法である。この方法は上記2つの方法に比べ被写体の記述力が高く、検索精度が向上している。
【0006】
【発明が解決しようとする課題】しかしながら、上記従来の3つめの、被写体を部品化して部品間の配置関係を検証することにより被写体の有無を検知する方法で、これまでに提案されている手法（特願平9－108701号：画像および映像検索方法）では、部品毎の色のマッチングに柔軟性がなく、照明などの撮影条件の変化の影響を受けやすいという欠点があり、十分な検索精度が得られないという問題があった。
【0007】本発明では、被写体を部品化して部品間の配置関係を検証することにより被写体の有無を検知する方法での、撮影条件の変化の影響を受けやすく十分な検索精度が得られないという欠点を解決し、より精度の高い被写体検索を実現することを課題とする。
【0008】
【課題を解決するための手段】本発明は、被写体の例示画像を検索キー画像として与えることにより、検索対象となる画像データおよび映像データから、前記被写体が

写っている画像や映像の一部分を提示する画像検索方法であって、前記検索キー画像中の色の分布を調べることにより、該検索キー画像を複数の部品に分解する第１の過程と、前記検索キー画像および検索対象画像を複数の粗さのブロックに分割し、各ブロック毎に色ヒストグラムを算出する第２の過程と、前記検索キー画像から分解されて抽出された各々の部品と前記分割された各ブロック内の色ヒストグラムを色の類似性を考慮して照合し、画像中の各点が各々の部品に属する確からしさを示す画像である部品画像を生成する第３の過程と、前記検索キー画像から生成された部品画像を用いて、該検索キー画像中の部品の配置関係をヒストグラム化した隣接ヒストグラムを算出する第４の過程と、前記算出された隣接ヒストグラムを用い、前記検索対象画像から生成された部品画像において、前記検索キー画像中の部品の配置関係と整合する部分の値を上昇させ、一方該検索キー画像中の部品の配置関係と整合しない部分の値を減少させることにより、各部品に属する確からしさの値を更新して背景部分から誤って生成された部品候補領域の影響を削減する第５の過程と、前記検索キー画像と同様に、前記更新された検索対象画像の部品画像から隣接ヒストグラムを生成する第６の過程と、前記検索キー画像および検索対象画像の隣接ヒストグラムを照合するすることにより、検索対象画像中の被写体の有無を判定する第７の過程と、を有することを特徴とする画像中被写体検索方法により、上記の課題を解決する。

【０００９】あるいは、被写体の例示画像で与えられた検索キー画像中の色の空間的な分布を調べることにより、該例示画像を複数の部品に分解する第１の手段と、前記検索キー画像および検索対象画像を複数の粗さにブロック分割し、各ブロック内の色ヒストグラムを算出する第２の手段と、色の類似性を反映した前記色ヒストグラムのマッチングにより、前記検索キー画像および検索対象画像中の各点が前記分解された各々の部品に属する確からしさを示す部品画像を生成する第３の手段と、前記検索キー画像から生成された部品画像を用いて前記部品の配置関係をヒストグラム化した隣接ヒストグラムを算出する第４の手段と、前記検索キー画像から算出された隣接ヒストグラムを用いて前記検索対象画像から生成された部品画像における前記各々の部品に属する確からしさの値を更新して背景の影響を削減する第５の手段と、前記更新された検索対象画像の部品画像から隣接ヒストグラムを算出する第６の手段と、前記検索キー画像および前記更新された検索対象画像の部品画像から算出された隣接ヒストグラムを照合することにより、前記検索対象画像中の被写体の有無を判定する第７の手段と、を有することを特徴とする画像中被写体検索装置により、上記の課題を解決する。

【００１０】本発明では、検索対象画像をブロックに分割し、そのブロック毎に各部品との色の類似性を考慮して照合することで各部品に属する確からしさを示す部品画像を生成し、色の変動を吸収するとともに、複数の部品間の隣接関係を大局的に評価して背景から誤って抽出される部品候補の影響を低減することにより、撮影条件が変化する場合にも、より精度の高い被写体検索を実現する。これにより、画像や映像に対して検索を行うデータベースシステム、および画像や映像の整理や属性情報の付与を行う画像編集システムおよび映像編集システムにおいて、画像や映像を検索キーとして所望の映像や画像を検索する処理の高精度化および処理時間の短縮を可能とし、大幅に作業効率を改善できるようにする。

【００１１】

【発明の実施の形態】以下、本発明の実施の形態について図を用いて詳細に説明する。

【００１２】以下に示す実施形態例では、静止画像を単位とした処理を行うので、検索キーおよび検索対象が、静止画像であっても動画像であっても同様に適用できる。例えば、動画像の場合の例として「映像中の特定の被写体が映っているシーンだけを抜き出したい」という検索要求が考えられる。この際には、その被写体が映っているフレームの一つを検索キーとしてユーザーが指定すれば良い。また検索対象が動画像であっても、フレーム単位に処理を行うことにより、静止画像と全く同様に扱うことができる。

【００１３】一般に人や物などの被写体は様々な背景の中に存在しているが、検索キー画像に、被写体と関係のない背景を含めたままでの被写体検索は技術的に極めて困難である。そこで被写体の映っている部分をユーザーが矩形等で囲むことにより、背景のない被写体のみの検索キー画像を得るものとする。

【００１４】本実施形態例での手法の処理の流れを図１に示す。

【００１５】まずはじめに、検索キー画像を複数の領域（部品）に分解する（１：第１の手段）。部品化するための手法としては、カラーセグメンテーションを用い色が似ている領域を抽出する方法用いても良いが、カラーセグメンテーションの際には局所的な色の比較を行うので、異なる物体や背景との接合が発生しやすい。また、物体表面のテクスチャの影響や陰影や遮蔽の影響で、物理的に一つの物体であっても複数領域に分割される場合も多い。ここでは、このような問題点を考慮した、より安定な手法（特願平９－１０８７０２号「画像セグメンテーション方法」）を適用するものとする。

【００１６】画像セグメンテーション方法では、まず、指定された画像中に一定数以上含まれる色を検出する。次に、検出された色毎に画像中の画素を周囲に膨張させ、異なる２色について膨張した画素同士の空間的な重畳をカウントし、その重畳する画素数が各々の膨張前の画素数と比較して一定の割合を超える時、その２色が空間的に分布が重なっていると判断し、これらを一つの部

品を構成する色として統合する。上記の重畳画素数のカウントと色の統合処理を全ての色の組み合わせに対して再帰的に行っていき、統合される色がなくなった時点で終了する。この終了時点で統合された色の集まり毎に、該当する色を持つ画素を画像中から抽出することにより、被写体を構成する部品毎に画像を分解する。

【００１７】この手法を用いることにより、従来のカラーセグメンテーションで発生した局所的な色の類似による不適切な接合を抑えることができ、かつ物体の色が複数の色から構成される場合でも、物理的な物体に近いまとまりのある部品の抽出が可能になる。

【００１８】図2に、特願平９－１０８７０２号「画像セグメンテーション方法」を用いて分解された部品の例を示す。ここでは、抽出された部品（部品１，２，３）の存在する画素を白く示してある。なお、部品の構成色と部品毎の色ヒストグラムを部品構成色データとして保持しておく。

【００１９】次に、画像中の各点が各々の部品に属する確からしさを示す部品画像の生成を行う。部品画像は、部品数と同じ数だけ生成される。部品画像の生成法を以下に述べる。なお、以下の処理は検索キー画像、検索対象画像に共通である。

【００２０】まず、画像（検索キー画像、検索対象画像）をブロック分割し、ブロック内の色ヒストグラムを算出し、一定の大きさに規格化する（２：第2の手段）。被写体の大きさが未知であること、および部品によってその大きさがまちまちであることに対応するため、異なるブロックサイズを階層的に設定する。これにより、部品の大きさが変動しても、後述する部品の候補領域の抽出処理によって、小さい部品は小さいブロックで、大きい部品は大きいブロックで抽出されることになる。なお、検索対象画像に対しては、処理の高速化のために色ヒストグラムの算出を事前に行うことも可能である。

【００２１】本手法では、部品の色の変動に比例した結果を得るために、色の変化と人間の直感が一致するL*a*b*表色系もしくはL*u*v*表色系を用いる。検索キー画像の各部品のヒストグラムx_i（L*，a*，b*）と対象画像中の部分ブロックのヒストグラムy（L*，a*，b*）を多次元ベクトルとして、ヒストグラム間類似度を、重み付き内積として算出する（式（１））。

【００２２】$I = x_i \quad W \quad y^t$　　（１）

ここで、$W = w_{ij}$は色ｉとｊの類似度を表す重み係数行列である。重み係数を$w_{ij} = 2^{-dij}$（ｄｉｊ：色空間でのｉとｊの距離）のように色空間での距離に応じて小さくなるように設定することにより、色の変動の大きさに応じた適合度が得られる。対象画像を部分ブロックに分割し、各ブロック毎に各部品に対する適合度を（１）式を用いて算出する。各ブロックに対し、各部品との適合度を算出することにより、画像中の各点が各々の部品に属する確からしさを示す部品画像が生成される。この処理を全ての階層に対して行い、部品毎に全ての部品画像の適合度の値を重ね合わせ、部品画像を生成する（３：第3の手段）。

【００２３】図3に、検索対象画像から生成、抽出された部品画像の例を示す。なお、ここでは各々の部品である確からしさが一定値以上であるブロックに色をつけ、全部品について重ね合わせて表示している。

【００２４】背景中にも、それぞれの部品と類似した色分布を持つ物体が存在する場合があるので、得られた部品画像からは誤った部品候補が背景中から抽出されることが多い。誤った部品候補が多い場合、被写体の有無を判定することが困難になるので、誤った部品候補を削減する必要がある。ある部品候補が被写体の一部であるのか、それとも背景であるのかを判断するためには、

１）被写体を構成する複数の部品が相互に隣接していること、

２）個々の部品としての確からしさが十分であること、

を判定する必要がある。ここでは、確率的弛緩法を用いて複数の部品間の隣接関係を大局的に評価して、背景から抽出される部品候補の影響を低減させるものとする。

【００２５】図4に、上記の手法による部品画像の更新の例を示す。部品をひとかたまりの領域として安定に抽出することは困難である。したがって、ここでは部品画像上の縦方向および横方向のライン上で連結した同一部品区間（セグメント）を処理単位とする。同一ライン上で隣接するセグメントペアに対し、そのペアが検索キー画像において隣接部品として出現する頻度に比例した更新値を算出する。すなわち、検索キー画像より生成された部品画像から隣接ヒストグラムを算出し（４：第4の手段）、これを参照して縦方向、横方向の全てのセグメントに対する更新値を算出した後、各セグメントに対応した部分ブロックの適合度の値を更新する（５：第5の手段）。これにより、検索キー画像中で隣接する頻度が高い部品の適合度は高くなり、背景から抽出される部品候補の影響を低減させることができる。

【００２６】図5に、部品画像の更新の効果を示す。（ａ）は更新前の部品画像、（ｂ）は更新２回の部品画像、（ｃ）は更新５回の部品画像の例である。更新計算により被写体の部品の隣接関係の成り立っている部分は残り、背景の多くは消滅していることがわかる。

【００２７】以下、空間的な配置関係の記述およびマッチングは、特願平９－１０８７０１号「画像および映像検索方法」を用いることにより実現される。すなわち、上記で生成され、更新された部品画像を用いて部品の配置関係をヒストグラム化した隣接ヒストグラムを算出する（６：第6の手段）。最後に、この検索対象画像から得られた隣接ヒストグラムと、前記の第４の手段により検索キー画像から得られた隣接ヒストグラムとを照合し、検索対象画像中の被写体の有無を判定する（７：第

7の手段）。

【0028】本実施形態例による手法の有効性を検証するため、1つのニュース番組中から抽出した43フレームを用いて評価実験を行った。被写体として計17フレームに写っている人物を選び、うち1フレームを検索キーの例示画像として43フレーム全体に対する検索結果を評価した。表1は検索結果を上位から順に提示した場合に正解をn個提示するまでに不正解がいくつ現れたか＊を示している。本手法により、含まれる不正解数が本手法によらない場合よりも減少していることがわかる。なお、不正解が少なく検索結果が良好な15フレームまでは被写体のサイズが通常の場合を示し、不正解の若干多い残りの2つのフレームは被写体のサイズが小さい場合を参考までに示している。

【0029】

【表1】

正解n個提示に含まれる不正解数（3回の平均値）

＼ 正解数(n)	5	10	15	17(全てを提示)
色交差法、更新なし	0.7	1.7	19.7	20.3
重み付きの内積、更新なし	0.0	1.7	8.7	15.0
重み付きの内積、更新5回	0.0	1.3	4.0	12.0

【0030】

【発明の効果】以上説明したように本発明によれば、従来手法と比較し、照明などの撮影条件が変化する場合でも、より精度の高い被写体検索が可能になる。これにより、画像や映像に対して検索を行うデータベースシステム、および画像や映像の整理や属性情報の付与を行う画像編集システムおよび映像編集システムにおいて、画像や映像を検索キーとして所望の映像や画像を検索する処理の高精度化および処理時間の短縮が可能になり、大幅に作業効率を改善することができる。

【図面の簡単な説明】

【図1】本発明の一実施形態例を示すの構成と処理の概要を示す図である。

【図2】上記実施形態例での部品化された画像の例を示す図である。

【図3】上記実施形態例での部品画像の例を示す図である。

【図4】上記実施形態例での部品画像の更新方法を示す図である。

【図5】（a），（b），（c）は、上記実施形態例での部品画像の更新の効果を示す図である。

【符号の説明】

1…検索キー画像を部品に分解する第1の手段

2…画像をブロック分割し色ヒストグラムを算出する第2の手段

3…部品画像を生成する第3の手段

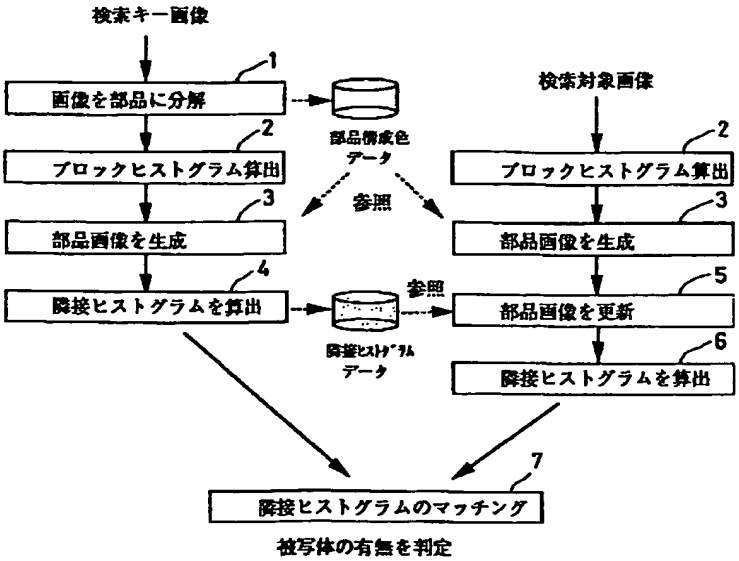
4…検索キー画像の部品画像から隣接ヒストグラム算出する第4の手段

5…検索対象画像の部品画像を更新する第5の手段

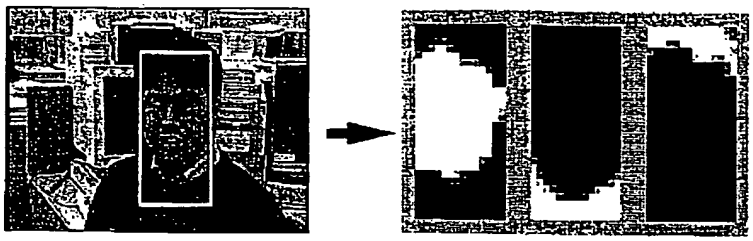
6…更新された検索対象画像の部品画像から隣接ヒストグラムを算出する第6の手段

7…被写体の有無を判定する第7の手段

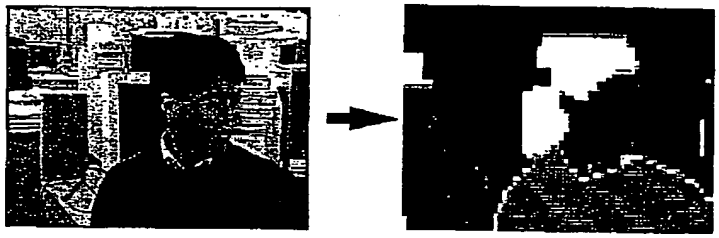
【図1】



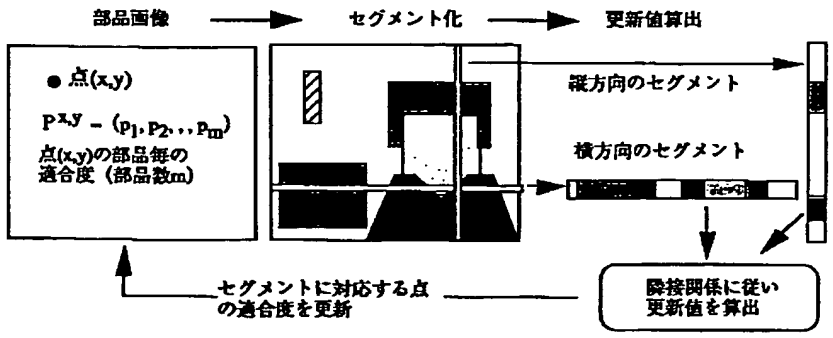
【図2】


検索キー画像（矩形部分）
部品1
（顔）
部品2
（セーター）
部品3
（髪）

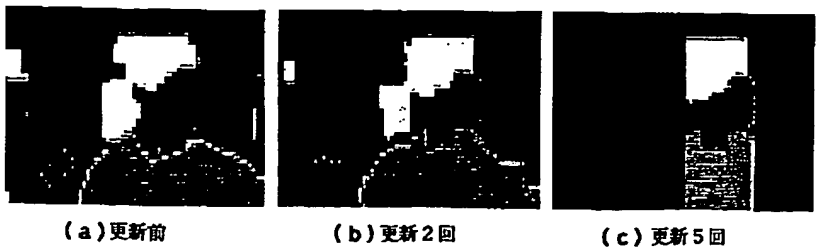
【図3】


検索対象画像
部品画像

【図4】


部品画像
セグメント化
更新値算出
● 点(x,y)
$P^{x,y} = (p_1, p_2, .., p_m)$
点(x,y)の部品毎の
適合度（部品数m）
縦方向のセグメント
横方向のセグメント
セグメントに対応する点
の適合度を更新
隣接関係に従い
更新値を算出

【図5】


（a）更新前
（b）更新2回
（c）更新5回

US-PAT-NO: 6512850

DOCUMENT-IDENTIFIER: US 6512850 B2

TITLE: Method of and apparatus for identifying subsets of interrelated image objects from a set of image objects

DATE-ISSUED: January 28, 2003

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Yaung; Alan Tsu-I	San Jose	CA	N/A	N/A

US-CL-CURRENT: 382/225, 382/195 , 382/218

ABSTRACT:

In one example given, a query for identifying interrelationships between image objects of a set of image objects is received from an input device. Each of a plurality of similarity values between all image objects of the set is compared with threshold criteria from the query. Clusters of image object identifiers are generated based on comparing and are visually displayed on a visual output device. .

10 Claims, 16 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 11

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Detailed Description Text - DETX (5):
Object server 106 is the repository for image objects stored in computer system 100. Users store and **retrieve image** objects from object server 106 through requests routed by library server 104. Object server 106 manages storage resources based on the storage management entities (such as volumes) that are defined through a system administration program. A database on object server 106 contains data about the exact location of each object. The database can be, for example, the IBM DB2 Universal Database or Oracle.

Detailed Description Text - DETX (8):
Users of client 102 of FIG. 1 can execute conventional image queries using the visual properties of images to match colors, textures, and their positions without having to describe them in words. Content-based queries can be combined with text and keyword searches for useful **retrieval methods in image** and multimedia databases. An image query includes a character string that specifies the search criteria for an image search. The search criteria typically includes (1) a feature name, which designates the feature to be used in the search; (2) a feature value, which corresponds to the value of the feature used; (3) a feature weight, which indicates

the emphasis placed on the
feature when calculating scores and returning
results; and (4) a maximum number
of results desired.

Claims Text - CLTX (8):

8. An apparatus, comprising: a similarity value generator, said similarity
value generator operative to generate similarity values between image features
of all image objects of a set of image objects, wherein the image features
include average **color, histogram color,** positional color and texture; and a
cluster generator, said cluster generator operative to generate at least one
subset of image object identifiers based on a first comparison between a
threshold criteria and each one of a first plurality of **similarity** values, the
first plurality of **similarity** values being between a first image object and
other image objects of the set, wherein the **threshold** criteria is a fixed range
of values designated by a user indicating a required degree of **similarity**
between the image features of the image objects in a cluster, and, in response
to determining that a **similarity** value between the first image object and a
second image object meets the **threshold** criteria, a second comparison between
the **threshold** criteria and each one of a second plurality of **similarity** values,
the second plurality of **similarity** values being between the second image object
and other image objects of the set; wherein said cluster generator operative
to logically group image object identifiers

associated with the first, second, and third image objects into a cluster if a **similarity** value between the second image object and a third image object meets the **threshold** criteria.

Claims Text - CLTX (9):

9. A method of identifying subsets of interrelated image objects from a set of image objects, comprising: comparing image features of each image object of the set with image features of all other image objects of the set, wherein the image features compared include average **color, histogram color,** positional color and texture; generating a similarity value for each comparison; comparing a **threshold** criteria designated by a user in a query with each one of a first plurality of **similarity** values, the first plurality of **similarity** values being between a first image object and other image objects of a set, wherein the **threshold** criteria is a fixed range of values designated by the user indicating a required degree of **similarity** between the image features of the image objects in a cluster; in response to determining that a **similarity** value between the first image object and a second image object meets the **threshold** criteria, comparing the **threshold** criteria with each one of a second plurality of **similarity** values, the second plurality of **similarity** values being between the second image object and other image objects of the set; and in response to determining that a **similarity** value between the second image object

and a third image object meets the **threshold** criteria, logically grouping image object identifiers associated with the first, second, and third image objects into a cluster.

Claims Text - CLTX (10):

10. A computer software product, comprising: similarity value generator code, said similarity value generator code executable to generate a similarity value for image features of each image object and all other image objects of a set of at least four image objects in response to a single request, wherein the image features include average **color, histogram color,** positional color and texture; cluster generator code, said cluster generator code executable to generate at least one cluster of image object identifiers, wherein the cluster generator code further includes: primary compare software, said primary compare software executable to compare a **threshold** criteria designated by a user in a query with each one of a first plurality of **similarity** values, the first plurality of **similarity** values being between a first image object and other image objects of the set, wherein the **threshold** criteria is a fixed range of values designated by the user indicating a required degree of **similarity** between the image features of the image objects in a cluster; and secondary compare software, said secondary compare software, in response to determining from said primary compare software, that a **similarity** value between the first

image object and a second image object meets the **threshold** criteria, said
secondary compare software executable to compare the **threshold** criteria with
each one of a second plurality of **similarity** values, the second plurality of
similarity values being between the second image object and other image objects
of the set.

Other Reference Publication - OREF (2):
"A New Approach to **Image Retrieval** With Hierarchical Color Clustering", Xia Wan, et al., XP-000779459 IEEE Transactions on Circuits and Systems for Video Technology, vol. 8, No. 5, Sep. 1998.